EDITORIAL

BECAUSE of Mr. Dewell's time being completely occupied with other matters during the past month, he has been unable to prepare the regular article in the 'Timber-Framing' series for this number. The concluding article, which will be devoted to the design of certain special structures and to a set of general specifications, will appear in our April number.

SOUTH AMERICA is a region that appeals to the imagination of almost everyone in the United States, including the engineer. Probably there are few engineers in the country who have not, at one time or another, cherished a desire to try their fortunes on that continent, for a time, at least, although, in most cases, it got no farther than a desire. Since the outbreak of the War, opportunities of all kinds in South America have received more attention than before. In this number we print a letter from Mr. Leon F. Price, an engineer of several years' experience in different parts of the southern continent, on the opportunities for engineers, and incidentally investors, in that part of the world.

IN another column appears a notice of the formation of the Petroleum Club of the University of California. Time was when no connection seemed to exist between oil-production and any of the universities, except the famous University of Hard Knocks, at which nearly all of the earlier oil-men obtained their training, and a very good training it was in a great many ways. By degrees, however, the value of technical training in the oil business became apparent, as it has in so many other lines of activity. The University of California has been among the first to offer courses that will be of assistance to the embryo petroleum engineer. While the newly-formed Petroleum Club is naturally composed largely of students and others connected with the University who are interested in this subject, it is hoped that a number of the oil-men in the Bay cities will also join the organization.

HOPE of obtaining relief legislation for the benefit of Californian oil-men operating on unpatented withdrawn land before the regular session next December has been practically abandoned. The present session will have ended by the time this reaches our readers, and at the time of going to press, the relief measures seemed to be crowded hopelessly to the background. Should an extra session be called, it is likely to be because of the war situation, and this will probably preclude the consideration of other subjects. Meanwhile, the Secretary of the Interior, Franklin K. Lane, who believes in conservation by use, has pointed out that the delay in perfecting plans for leasing the Government oil, coal, and phosphate-lands under terms that would encourage development, may have serious results in case of war, when we would need all our resources. In such a case there would be no time for the long process of drilling wells in an undeveloped and perhaps unproved territory.

Defects in Municipal Ownership

Municipal ownership sometimes seems to be a very desirable thing. There is something attractive about the idea of the people running their own business and paying themselves the profits. However, with the kind of management usually available for municipal enterprises, the results are frequently unsatisfactory. The recently dissolved Richmond Municipal water district is a case in point. A few years ago, the citizens of Richmond, California, and some of the adjacent unincorporated territory, decided that they wanted an improved water-supply. The natural thing to do, one would suppose, would have been to employ some one who really knew how to investigate the entire situation and give advice regarding the best course to pursue. Instead a district was formed and several well-meaning men were elected to the board of directors. Several plans were considered, none of which seemed to meet with the approval of the people. Finally after about $40,000 had been spent, a movement to dissolve the district was started and a large majority of the voters decided in favor of so doing. Things are now where they were at the start except that the $40,000 is gone. Nobody knows what source or what method of transmission would be the best. In fact, nobody knows whether or not the district-plan is the best way for that region to handle its water-problem.

Another instance of inefficient municipal management is now being furnished at Fresno, California. Plans for a sanitary and a storm-sewer system were prepared last year by the city engineer, and checked by a firm of consulting engineers from Los Angeles. When bids for the construction of the sanitary system were opened, it was found that the lowest bidder was a new company, composed of men with small experience in contracting. The figure named was much lower than the other bids or the estimate of the consulting engineers. Apparently, the investigation conducted by the city covered only the financial responsibility of the contractors, and not their construction experience. The contract was, however, awarded to them and work was commenced last summer. Soon after this, the contract was assigned, with the consent of the city, to a third party. The contractor's forces appear to have followed the now-famous policy of 'muddling through,' until the Grand Jury decided to take a

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hand, and employed an outside engineer to investigate the work. He reported that the rock being used was inferior, that some at least of the concrete was of poor quality, that the reinforcement was deficient, and that the work was progressing about half as fast as it should in order to finish on time. Acting upon his recommendation, the Grand Jury advised that a competent engineer be appointed to have entire charge of the sewer work. Whereupon, the city council accepted the resignation of the city engineer and appointed him 'sewer engineer,' to have charge of the construction of the sanitary-sewer system, and also of the storm-sewer system, contract for which is soon to be awardeed. Compensation will be on a percentage basis and will amount to several times his former salary. One of the deputies in the office has been appointed city engineer.

It is impossible to find either rhyme or reason in this action by the city council. If the sewer work is going as well as can be expected as far as the city engineer's office is concerned, there is no reason for any change at all. If the city engineer is competent to handle the work, but has been handicapped in the past by insufficient help, it would be simpler and cheaper to employ additional deputies. If he is not competent to handle the work, it is not necessary to increase his powers and his compensation.

It is admitted that sewer systems must necessarily be in charge of city officials, but the Fresno case does not encourage extension of the field of municipal ownership.

A Vicious Bill for Licensing Architects

The attention of engineers, contractors, oil-operators, and other persons having to do with building construction is called to Assembly Bill 1126, introduced at the present session of the California legislature, and entitled 'An Act Providing for Public Safety in Buildings Within the State of California by Regulating the Construction, Alteration, and Repair of Same, and to Provide Penalties for the Violation Thereof,' but in reality is a bill to tie the entire building industry of the State, hand and foot, and to deliver it to certain favored architects. The bill was prepared by a member of the Southern California Chapter of the American Institute of Architects and has received the endorsement of that body. As far as we can learn, the San Francisco Chapter has taken no action with regard to the measure.

The bill would supersede and repeal the present architect's license law. It provides for a Board of Architecture appointed by the Governor and composed of six architects and one civil engineer, indicating presumably the importance of the two professions in the eyes of its framers. This board is to hold examinations at stated intervals and issue 'certificates to practise architecture.' Architects now holding certificates are not required to take the examination. Examinations are open to practising architects of five years' experience outside the State and to architects' employees who have had five years' experience. This disqualifies practically all structural and other engineers from even taking the examination. It is further provided that the construction, alteration, or repair of any building, when such work affects the safety or stability of the building, must be under the supervision of a certified architect or an employee of a certified architect. An exception is made in the case of single-family dwellings.

There are two principal objections to the bill as it stands. One is the attempt under the guise of a safety measure to assist the architects in usurping the functions of the structural engineers, and to compel the structural engineers, if they are to remain in practice at all, to operate under the protecting wing of some architect. Bills of this character are frequently introduced in one State legislature or another, and such a law was actually passed in Illinois not long ago, with unfortunate results. With all due deference to architects as a class, they are seldom experienced in the calculation of stresses, nor have they much knowledge of the strength of materials as affected by construction methods. In fact, in almost every consideration connected with the safety of a building the architect must, or at least should, defer to the structural engineer, while under the proposed measure the structural engineer would be compelled to defer to the architect. Whether such a condition would make for safety, we leave to our readers.

Another objection to the proposed measure is that its provisions are entirely too sweeping. Apparently, a contractor could not build a temporary bunk-house, or an oil company a boiler-shed without employing an architect. In fact, it seems probable that a strict construction of the bill would place an architect in charge of the erection of every oil-derrick. Whether or not a survey-party could put up a tent without coming under the provisions of this act would probably require a Supreme Court decision. It may be admitted that in such cases as have been mentioned, the law would not be likely to be enforced, but even so, the act would be like other dead-letter laws, a tacit encouragement to general lawlessness, and a whip in the hands of the blackmailing official.

It is hardly conceivable that this bill should become a law, but it must be remembered that equally iniquitous measures have slipped through the legislature while no one was looking. It is important that legislators be made acquainted with the true purport of the bill, which is not indicated at all by the title. The San Francisco Association of Members of the American Society of Civil Engineers has adopted resolutions condemning the bill, and has appointed a committee to oppose its passage, and, if necessary, to go to Sacramento when the bill comes up in conference. Similar action should be taken by other engineering societies, by the contractors' associations, and other organizations of persons affected by the bill. We have already called attention to the fact that this is a matter of vital importance to the oil-men. Above all, it is important that everyone interested in the defeat of this measure should write concerning it to as many senators and assemblymen as he thinks he can influence. This is a matter that calls for instant and vigorous action.

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REVIEW OF THE MONTH

THE annual report of the Board of Direction of the American Society of Civil Engineers gives some interesting facts regarding changes in membership during the past year. An increase is noted in the number of both members and of associate members, but the number of juniors shows a decided reduction, from 803 to 725. The admissions by election were 119, while 129 juniors were transferred to the grade of associate member. In addition 23 juniors resigned, while 43 were dropped from the rolls of the Society. There were 2 deaths. Among the approximately 3500 associate members there were 41 resignations and 30 dropped, and the proportion was even less among the full members. It is of course, true that a number of juniors were dropped because they had not qualified for a higher grade of membership. Nevertheless, these figures would indicate that the younger engineers are coming to regard membership in the Society either as entirely unnecessary, or else as something to be postponed until they have established themselves, and also that a large proportion of those who are juniors become dissatisfied and leave the Society.

IT is self-evident that membership in the Society could be made of direct value to the young engineer, as well as giving him opportunities for service to the community that he would not otherwise have. If membership in the Society is at the present time worth while to the young engineer, it is the duty of the members to show this to the young engineers of their acquaintance. If it is not worth while, it should be made so, by reducing the dues to juniors, by giving members more for their money, or by both methods. It may be, in these days of the high cost of living and depressed conditions in some lines of engineering activity, that the dues to juniors are too high, and that the Society could better afford to reduce them, rather than to continue to lose junior members.

SEVERAL methods have been suggested for giving both juniors and corporate members more return from their dues, mainly in the direction of improving conditions of employment. The San Francisco Association of Members now maintains an employment bureau in charge of the secretary. Along these same lines was the plan proposed at the annual meeting of the Society in January, for an organization to assist members in marketing their services. Such a plan would, we presume, be more comprehensive than an ordinary employment bureau. Complete standardization of rates for similar services, for both salaried positions and consulting practice, would be impracticable and probably undesirable, but a committee with the backing of the Society could accomplish a great deal of good in this line, as well as in employment activities.

ABANDONMENT of the Sacramento River flood-control project would probably occur, if some bills now under discussion at Sacramento should be passed. One of these bills provides for the repeal of the Reclamation Board Act. This would probably result in the abandonment by the Federal government of its part of the work of improvement of the Sacramento river, since the Government aid was made available with the understanding that the State and the owners of lands subject to overflow would do their part. Another measure provides that the parts of the 14 counties included in the Sacramento and San Joaquin drainage district shall vote in November on the question of the abandonment of the district. Even if the voters decide to continue the district, work would necessarily be practically at a standstill until the question was decided. To many of the voters the question will seem to be: shall I be relieved of paying further assessments to the district? Under such conditions, there is grave danger that the district would be abandoned, with results, almost, if not quite as bad as would follow from the repeal of the Reclamation Board Act.

THERE are a number of persons and corporations dissatisfied with the conduct of the district and of the general reclamation-plan. A large number of residents of Sutter county object to the position chosen for the Sutter by-pass, some large land-holding corporations in the southern part of the district are now attacking the constitutionality of the district, in order to escape paying assessments, and there are, of course, many landowners throughout the district who believe, rightly or wrongly, that they are not getting full returns from the assessments that they are called upon to pay.

IT is not to be expected that a large project such as the general reclamation-plan could be carried on without some apparent injustice, but the remedy for this lies in appeal to the Reclamation Board, and, if necessary, to the Courts, rather than in an attempt to undo what is, at least, a beginning of a comprehensive plan for flood-control and navigation in the Great valley of California. To abandon the district or to abolish the State Reclamation Board, means simply a return to the disorganized conditions of a few years ago, when each reclamation district built levees against its neighbor, rather than against the river. It is to be hoped that

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the Legislature will take no steps toward bringing about such a condition.

THE activities of the Petroleum and Gas Department of the State Mining Bureau during the past year and a half were mainly concerned with getting the work started and with the supervision of new wells, although several cases of old wells where water had not been shut off were investigated and remedied. Now, however, the Department has reached a point where it is in a position to consider some important cases where wells on one property are believed to be the cause of water trouble on adjacent properties. Mr. R. P. McLaughlin, State Oil and Gas Supervisor, has issued his first formal order in the case of a well in the Coalinga field. In accordance with the policy of the Department to give the owner of a suspected well, every possible chance before ordering the well to be plugged, a careful field investigation is to be made before deciding upon the measures to be pursued. Several other complaints are now being investigated by the Department. In some cases recently considered, no formal action was necessary, since all the operators were so thoroughly convinced of the fairness of the Department that they stood ready to follow its recommendations.

HIGHWAY construction in California seems likely to be particularly active during the coming season. Contracts for building 60 miles of concrete-paved highways will be awarded this month in Stanislaus county alone. Contracts for 40 miles of highway have already been awarded in this county, 15 miles in January and 25 miles in February. The entire system will comprise 124 miles of highway, nearly all to be paved with concrete. The bond issue of $1,482,000 was voted last November. The Stanislaus County Highway Commission evidently feels that by letting the work early in the season greater competition and lower prices may be obtained. Sacramento county voted bonds for $1,750,000 in October. The highway problems in that county are more difficult of solution than in Stanislaus, so that it has required more time to get ready to ask for bids. However, bids are now being received for furnishing cement and aggregate, and a call for bids on construction of some highways is expected soon. The mileage of the system is about the same as in Stanislaus county, but the cost is greater, mainly because of more expensive bridges being required. In the southern part of the State, Orange county has completed its highway system, and the systems of Riverside and San Bernardino counties are nearly complete. In Kern county, expenditure of the original bond issue of $2,500,000 voted in 1913 continues, and there is some talk of a supplementary bond issue. In Kings county, about half the system being constructed under the $672,000 bond issue voted two years ago has been completed. It is estimated that in addition to the bond issue, $100,000 more will be required to complete the proposed system. This will probably be met from the general levy.

ELECTIONS are to be held during the coming month to vote on bond issues for highway purposes in two counties, Santa Clara and Tulare. The amount proposed is $1,500,000 in Santa Clara and $2,200,000 in Tulare county. Two years ago the voters of Tulare county defeated a proposed issue of $1,500,000 for this purpose, but the good-roads sentiment has been growing ever since, so that the prospect of the issue being carried appears to be good. In Santa Clara county there is strong opposition to the bond issue. It is headed by the chairman of the present Board of Supervisors, who has declared himself in favor of continuing the system now being followed of constructing several miles of permanent highway each year from the general tax-levy. This plan is being followed in Contra Costa county, where about $150,000 is raised each year by direct taxation and expended on construction of permanent highways.

WHEN the large amount of municipal work is also considered, it would seem that highway contractors would be able to keep fairly busy until July, when the money from the $15,000,000 bond issue voted in November will become available for the work of the State Highway Commission. Turning to proposed work that has not yet reached the stage of definite plans, there is probably some discussion of permanent highways in most of the counties of the State. In Santa Cruz and Merced counties, plans are now being prepared for county highway systems, and it is expected that bond-elections will be called before long. Plans are also being considered in Placer county and Solano county has requested advice from the U. S. Office of Public Roads.

OPPOSITION to any and all bills providing for centralized control of the construction and maintenance of county highways was the substance of a resolution adopted at the convention of county supervisors of California. Representatives of 45 out of the 58 counties in the State were present, and the vote is reported to have been unanimous except for one supervisor from Orange county, whose name is not given, but who is, presumably, Mr. S. H. Finley, builder of the Orange County highway system, whose campaign for supervisor on this very issue has already been discussed in these columns. We do not believe that the wish to retain the petty patronage incident to local control of highways was the dominating motive in the minds of many of the supervisors who voted for this resolution. A distrust of technically trained men for so-called 'practical' work, together with fear of a certain amount of State control of appointments which is provided in all of the bills, were probably the more potent reasons. Yet this same convention, in the face of the old-time prejudice against 'book-farmers' declared itself in favor of the county farm-adviser system. This was also in spite of the fact that State officials have considerably more authority in the selection of farm advisers than they would in that of the highway engineers proposed.

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DISCUSSION

Exclusion of Water From Oil Formations

The Editor:

Sir—To those familiar with the oil business it is unnecessary to state that the cementing process, with its several mechanical variations, holds the centre of the stage, in California at least. The mud-laden fluid method is being tried out with apparent success in the Oklahoma field and will, no doubt, play an important part in the economics of the petroleum and gas industry.

I have recently noticed several failures with cement which illustrate the necessity of caution. A 10-in. string was cemented but did not set. An 8¼-in. string was also run in and cemented, and another failure was the result. The management grew suspicious and experimented with samples of the cement at the surface, using water from the hole and also from their water-well in the tests. None of these samples set. The tests would have been more complete had they included samples mixed with distilled or other suitable water so that the blame could be fixed upon either the dissolved salts in the water or on the cement itself. Of course it was unfortunate that the tests were not made before the cementing operations began, and the moral is apparent. Citing another case of failure, a 10-in. string was cemented in a rotary-drilled hole with 21 tons of cement, after which water was found coming in around the shoe. It is believed that the rotary-mud was not thoroughly washed from the hole before the cement was introduced and that the cement did not make a suitable bond with the walls at all parts of the circumference of the hole. This probably allowed the water under pressure to form channels around the outside of the mass of hard cement. It might be argued that the mud-laden fluid back of the cement should hold the water. It would be quite likely to do this if a suitable shoe had been driven into a tapered hole. Another point to consider is the condition of the contact of the cement and mud, as dilution of the cement with mud may form a zone of weakness. In the case mentioned the mud probably had not packed around the casing for any distance, and the resistance to water could not be as great as in the regular use of the mud-laden method. The reason for using such a large quantity of cement was that it was known that the rotary had made an exceptionally large hole, which was shown by the drill-pipe being bent considerably.

There are some who believe that the old-fashioned formation shut-off is better than the ordinary cementing practice. When a long suitable shoe is driven into a sticky clay, and judgment is used, the chances for success are excellent. Ordinarily the bottom of the hole is not tapered when using cement. Why not combine the two methods and drive the casing into a tapered hole after, or simultaneously with, the introduction of cement on the outside? There are then two chances of success, and the cement would at least protect some of the casing from corrosion. The fact that cement will not harden, when kept agitated by the action of gas or water, is the cause of a large proportion of the failures.

The principal object of this communication is to obtain information, if possible, concerning facts or opinions on another method of handling the water problem in the oilfields. I have never seen any data in print regarding the process, and I find that few oil men are familiar with it. As I understand that it was invented nearly twenty years ago and used successfully for a time, I am interested in learning the reasons for its disappearance, particularly because I have recently seen the principle successfully and easily applied. The process, called tamping, is said to have been first used in the Fullerton field by William Plotts. H. G. Anderson of Coalinga, an oil man of long experience, has used it successfully and believes it to be an excellent, and perhaps the best method of excluding water, especially bottom water. He knows of no reason for discarding it except that the inconvenience of 'spudding' the pipe puts it in disfavor with most of the drillers and therefore it was not given a fair chance.

In the tamping method, either oil-sand or a mixture of sand and resin is used. A mixture of one part resin to seven of sand has been found good. The underground temperature is usually high enough to soften the fine particles of resin readily and they then form a somewhat plastic combination with the sand. The action of 'spudding' a string of casing, as this mixture is fed between the two casings, makes a tough water-resisting filling-material which seems to bond well with the walls whether mud is present or not. The tamping force of a heavy string of casing causes an adjustment of all the material in the hole with the effect of excluding water. Proper depth of tamping must be considered and the material must be fed slowly. It is said that, when necessary to remove casing after it has been tamped, it can be accomplished with but little damage to any formation that must be preserved intact around the hole. If a large proportion of resin is used it will probably be necessary to use iron scraps or other hard substances to facilitate the re-drilling.

It seems that the process was originally used as a sort of secondary method or one of last resort. It was probably applied after a formation shut-off had failed, or after casing had been perforated by corrosion, or for shutting off bottom water. In a recent case the 10-in. casing was cemented and found satisfactory. Several months later, when the well was producing, water broke in around the shoe. The oil string was 8¼-in., so 6¼-in. casing was inserted and tamped off by spudding the 8¼-

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in. string to a point above the 10-in. shoe. It appears that this method might be used at the start if its advantages were decided enough to offset a decrease in diameter of casing. It also appears, however, that it may be found possible to use but one string in a well. If a rotary hole is drilled to accommodate, say, 10-in. casing, this string could be put in, then 8¼-in. casing inserted and tamped off. The 10-in. casing could be withdrawn and the 8¼-in. casing would commonly be left as the water-string. If conditions were favorable for drilling into the oil-sand with the rotary it seems possible that but one string would have to be used. The tamping can be carried to a point as high as desirable so that all of the important strata could be sealed, and the tamping could be broken at any points to allow production from any zone. If one string were used and it was desired to produce from, or leave the well in readiness to produce from several sands, the mechanical details could, no doubt, be arranged satisfactorily. If it were deemed necessary, 'stops' to break the tamping could be placed above the oil-sands, although this has been found unnecessary when the hole is not too much larger than the tamping-string. The 'stops' could be made of hemp and arranged so that the tamping-string would spread them when coming down. If these were used there would have to be a system of placing them by unscrewing and inserting again with an additional 'stop.' Special steel collars and left-handed threads might be employed to advantage. After tamping had been done above the last productive measure, the filling could be carried to the surface or near it and, if this was properly done, no water could come in contact with the casing. It is believed that corrosion of the casing would be negligible.

When bottom-water is encountered, the following method has been used with success against a strong flow of water that could not be curbed by the ordinary method of stuffing before cementing. A string of suitable size, smaller than that which entered the bottom-water, is inserted to bottom. It should be perforated for the bottom-water and carry a valved heaving-plug above the perforations. The tamping is started on the outside and the flow is handled through the plug. After finishing the tamping, the valve in the plug is closed and the water is confined below it. A little cement may be dumped on top of the plug and the casing cut and removed.

It seems that the tamping method could be used with decided advantage in many cases, that it was the victim of the early-day drillers, and that it is well worth consideration as a solution to some of our oil-well problems. Comment by anyone will be appreciated.

H. W. Bell.

Coalinga, California, February 13.

Bridge-Designing and the Recent Failure at Spokane

The Editor:

Sir—The practice followed by many of the smaller cities of doing their own bridge-designing usually results in increased cost of the structures and frequently in bridge failures that cost the municipalities large sums for damages and throw discredit on engineers generally.

The city of Spokane has had enough trouble of this kind to teach it a much needed lesson, and its experience should go far to deter other small cities from designing their own structures in case they cannot afford to hire expert bridge engineers to conduct their bridge departments. The Division Street bridge in Spokane, which failed about a year ago, was a striking example of the overloading that is being allowed on old structures all over the country, without having expert advice as to the loads that such bridges will carry, or the method of strengthening them if possible. Spokane has also persisted in designing its reinforced concrete bridges. Practically all of them have cost double the amount they should, partly because many of them have been built by day labor, and partly because of uneconomical design.

The construction of the Post Street bridge in Spokane, which was a long-span reinforced concrete arch with inadequate rise, was in charge of the same engineer that supervised the Monroe Street bridge when the false-work failed on that structure. The engineer lost his life on the bridge just before the failure of the structure, so that we must be charitable in discussing the failure in so far as he is concerned, but the real people to blame are the 'higher ups' who will not spend money for expert advice regarding such important bridges. There seems to be no question but what the Post Street Bridge failure was because of the false-work giving way, since all the concrete arch was not placed yet. It is believed that part of the false-work was on solid rock and part on a gravel bottom, this latter portion resting on sills. Probably these were undermined, resulting in the collapse of the false-work and the span itself.

There can be no question but what the larger cities should have their own bridge departments, and by larger cities I mean such cities as New York, Philadelphia, Chicago, and San Francisco. Even they should call in real expert consulting bridge engineers (not some other species) on all important structures, at least to check and approve the plans for ordinary bridges, and to take an active part in the design and construction of the more important structures.

The principal work of a city bridge department should be to inspect existing bridges, see that they are kept painted and in repair and that no work is done on them that will impair their strength, nor heavy floors or loadings allowed that are dangerous.

While discussing such an important matter, it is well also to call attention to the fact that not only cities, but many of our corporations are making mistakes of the kind enumerated above. The directors of one large corporation assumed that because they had engineers who were college graduates, and who had studied bridge engineering, that they could do their designing

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better than consulting engineers. In one recent case a plate-girder bridge was designed without the proper splicing of the flanges so that the unit stresses ran up to over 23,000 lb. per sq. in. The cover-plates were riveted, using a 6-in. spacing at the centre of the span, and 12-in. toward the ends of the plates with the idea that the point of greatest flange-stress required the greatest number of rivets!

We cannot expect to live long enough to see these troubles overcome, on account of the fact that our universities are turning out engineering graduates by the hundreds who believe themselves to be bridge experts simply because they have had a year or so of study of bridge stresses, and have perhaps designed a few details as a part of their college work. The practising engineer who undertakes special work for which he has neither training nor experience, is also to blame for much disgraceful work on bridges and other engineering structures. Whenever and wherever engineers get wise enough to overcome all such foolish endeavor, then and there will the engineer get the respect and consideration that is due to the members of the profession.

CHARLES EVAN FOWLER.

Seattle, February 15.

Opportunities for American Engineers in South America

The Editor:

Sir—So much has been written regarding the opportunities for business and professional men in South America that any remarks upon this subject might seem superfluous. For the last few years, the continent to the south of us has been lauded, not entirely without reason, as the coming El Dorado. The extreme optimists have cried that everyone, no matter who, how, or where, should go south, in emulation of Horace Greeley's 'Go West.'

The engineer's endeavors in South America have, in the past, been concerned mainly with creating facilities of transportation. Building trails through the tropical jungles, railroads to the high plateaus or over extensive prairies, deepening rivers, and creation of harbors where none had existed, all tended toward better means of transporting products, that had been valueless to the sparse native population, to an eager and waiting world.

Americans in general have a vague conception of South American geography and distances. How many Americans know that the easiest and safest route from Lima, the capital of Peru, to Iquitos, in the same country and only a few hundred miles distant in a straight line, is *via* the Panama Canal and up the Amazon river. The trip over the Andes mountains and through the tropical jungle, although partly spanned by railroad, is feasible only to the hardiest of pioneers.

The climate of our sister continent is perhaps the greatest enigma to the stay-at-home American, 120° F. in the shade is the prevailing idea. Of course, one is not compelled to stay in the shade. The frigidity of Tierra del Fuego and the plateaus of the Andean ranges from Chile to Colombia is conceivable only when the subject of special testimony. It is granted that in the Amazon valley and in the jungle regions of the northern half of the continent, the suffocating, humid heat so damaging to health, does prevail, especially during the rainy season. But, and one is relegated to the Ananias Club for making the statement, at Guayaquil, the so-called 'pest-hole of the Pacific,' only a few degrees from the equator and at sea-level, in the months of August and September, temperatures of 18 and 20° C. are common, and a blanket is frequently welcome.

The early settler of South America, of whatever nationality, was a hardy pioneer. He was contented to make his way over its steep mountains or through dense jungles, by horse, mule, canoe, or even on foot. His life was a short but a merry one. If he escaped the venomous snake, the supposedly inoffensive mosquito laid him low.

The new generation, however, does not care to ride for months on horse-back in order to get somewhere. It is still a 30-day ride from Quito, Ecuador, to Bogota, Colombia. Measure the distance on the map. It will surprise you. The people want modern means of transportation and communication. They want their families to live in sanitary cities, and to have some of the comforts obtainable in other parts of the world.

To accomplish this, South America turns to foreign capitalists and gives them the benefit of its trade. Its own capital is mainly employed in the self-help, co-operative bank *cedula* system, which has served as a model for our farm-loan banks. The engineers and supplies naturally 'follow the flag' of the country that furnishes the capital.

Up to August 1914 most of the money invested in South America came from Europe. American firms that wanted to operate in South America were obliged to maintain European offices and a European organization. The War has changed all this. The influx of European capital has been stopped. The channels of trade have been changed abruptly. Development projects that have depended upon European capital are marking time, and there is little hope of resumption. Only the few projects backed by American capital are in full swing.

The American engineer's opportunity in South America is ripe. However, it lies parallel with the opportunity of the American banker. Without the banker, the engineer can do but little. The engineer, whether he be the 'scout' or the one who carries out the project, can find his opportunity only through the co-operation of the banker.

The banker or engineer who wants to do business in South America must not be half-hearted about it. The man who would not give five cents for all of Latin America, and the one who is always thinking of getting back to God's country, had better stay at home. But for the man who has faith that conditions can be changed, that development does create value, and, who, once in the country, is willing to 'stick,' the opportunity is there and the time is now.

LEON F. PRICE.

San Francisco, February 20.

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Methods of Construction of Rogers Pass Tunnel

A recent number of the *Proceedings* of the American Society of Civil Engineers contains a description of the methods of construction of the recently completed Rogers Pass tunnel, by A. C. Dennis, engineer for the general contractors. This is a double-track tunnel, five miles long, on the Canadian Pacific Railway in the Selkirk mountains in British Columbia. It is part of a local improvement ten miles long in all for reducing grades, curvature, and summit elevation. About 500 ft. of rise and fall will be saved. The mountains in the vicinity of the tunnel are rough, and are heavily timbered except in the path of the numerous snowslides. The rainfall is heavy and the annual snowfall is between 30 and 50 ft. The minimum temperature since the work was started was –32° F. Except for 1200 ft. at the east end and 400 ft. at the west end, the tunnel

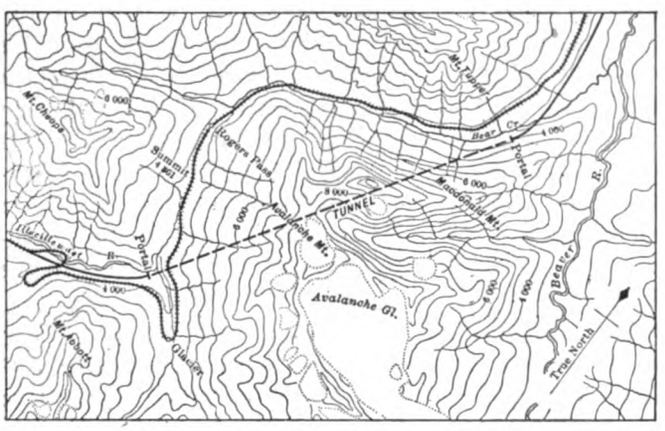

FIG. 1. MAP OF VICINITY OF TUNNEL.

is in solid rock, mainly quartzite, but with considerable schist. The dip at both ends of the tunnel was to the west and rather steep, and about level or slightly to the east toward the centre. The strike made an angle of about 60° with the tunnel-axis. There were many local irregularities and some faulting. Except where it was broken by faulting, the rock was not timbered during construction. The maximum rock temperature was 75° F. Little water was encountered.

Contract for the work was awarded to Foley Bros., Welch & Stewart in June 1913, and work commenced soon after that time. This firm was not the lowest bidder but undertook to complete the work in less time than the other bidders, by the use of the 'pioneer-heading' method. By this method, which had never been tried before, a 'pioneer heading' is driven entirely outside the regular tunnel-section, cross-cuts being made at intervals to the regular tunnel-heading. This pioneer heading served as an intake for forced circulation of fresh air through the cross-cuts and out through the main tunnel, enabling work on the main-tunnel enlargement to be resumed immediateley after blasting. It also served to take excavated material from the headings without interfering with any of the work in the main tunnel. Pipe-lines for bringing water, compressed air, and ordinary air to the headings were laid in the pioneer heading and did not have to be disturbed by the work of tunnel-enlargement. The pioneer heading was also of general assistance in enabling the work in the regular heading and in the enlargement to proceed at the same time without interference.

Permanent camps and power-plants were established at each end of the tunnel. Each plant had five 150-hp. boilers. These were usually run at a considerable overload. Ingersoll-Rand compressors were used, two-stage for low pressure, and four-stage for high pressure, with inter-coolers. The capacity of each plant was 4000 cu. ft. of air per minute at from 100 to 125 lb. per sq. in. pressure at the compressor, and 1500 cu. ft. at 1000 to 1100 lb. The compressed air passed through an after-cooler, and there was little trouble from freezing of moisture in the air when exhausted from drills, pumps, and blowers.

At both ends the place for starting the pioneer tunnel was selected so that rock was reached in as short a distance as possible. When rock was reached, the pioneer heading was made 7 ft. high and 8 ft. wide. It was driven with light hammer-drills, using hollow steel, with water attachments. Three drills were used in general, and four in the harder rock. Spare machines were kept at hand, to be used in case of breakdowns. No repairs were made in the heading. The drills were mounted on a light horizontal bar, about 18 in. below the roof-line. Air and water were brought on a single line to a manifold near the drills. The ventilating-pipe was a 12-in. wooden water-pipe, connected to Connersville blowers. The pipe was hung close to the roof and was carried to 20 ft. from the face, but it was seldom damaged by blasting. The blowers were started about the time the first hole in each blast was fired, and they were run for 20 minutes. The men got back to work in from 5 to 10 minutes after the blast was fired. Compressed air was not used at all for ventilating. After a blast the drillers followed the smoke back, barring down the roof, bringing explosives for further blasting, and wetting the sides, face, bottom, and roof of the tunnel with the water-hose. The shovelers commenced clearing the track and loading the material into the cars. Shoveling-plates were used at the face of the heading and on the side away from the track. One-half yard cars were used running on an 18-in. gauge track.

When no further blasting was required, the bar was placed in position and drilling continued. The bottom

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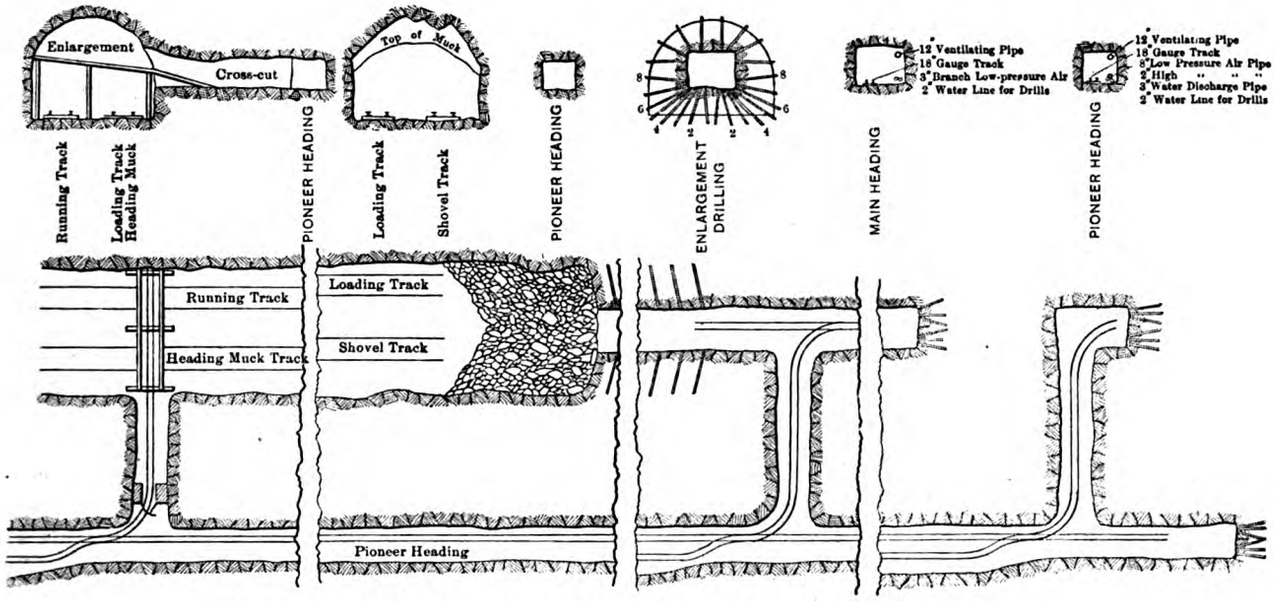

FIG. 2. SKETCH SHOWING CONSTRUCTION METHODS IN PIONEER AND MAIN TUNNEL.

holes were fired last and loaded the heaviest. This threw the material back from the face, and there was seldom any shoveling to do before the drilling could be started. There were two helpers to three drills. Two men loosened the material with picks and three men shoveled it into a car, while three other men stood by with an empty car ready to fill it while the other was being hauled out of the heading. At first the hauling was done by the men, but compressed-air locomotives were used on most of the work. The air-pressure at the drills was maintained at 90 lb. This required 125 lb. at the compressor toward the end of the work. Air, water, and ventilation lines were maintained by a pipeman and helper.

From 21 to 28 holes, according to the character of the rock, were drilled in the face of the pioneer heading. The explosives used were 40 and 60% low-freezing gelatine. with No. 8 caps. Blasting in the headings was all done with fuse. A round was usually 6 ft. Where re-blasting was unnecessary two rounds could be made during an 8-hour shift. Three shifts per day were worked, and only two days were lost during the work, both because of breakdowns. The pioneer-tunnel gang also drove the cross-cut to the main heading. These were placed from 1500 to 2000 ft. apart. The rock portion of the east pioneer tunnel was driven 2 miles in 1½ years. The maximum monthly progress was 776 ft. The portion of the west pioneer tunnel in rock was driven 1½ miles in less than one year. The maximum monthly progress was 932 feet.

There was 1200 ft. of glacial drift at the east end of the tunnel. In general, this part of the tunnel was driven in the usual manner, by running wall-plate drifts, placing the arch-segments of the timbering, and then taking out the remainder of the heading excavation. The tunnel-bench was taken out with a steam-shovel without first running drifts for posts. The resulting settlement of the wall-plates was small, in no case more than one inch, and considerable time was saved by this method. A locomotive-crane was used to deliver the timbers. This part of the work took about six months.

At the west end there was 400 ft. of soft ground, the west portal being under a swamp at the intersection of

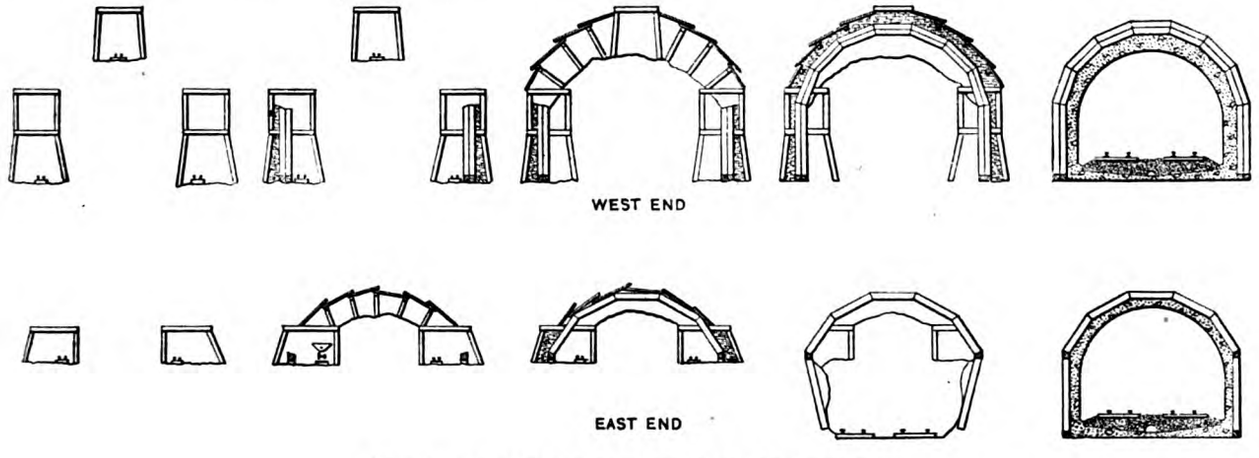

FIG. 3. CONSTRUCTION METHODS IN SOFT GROUND.

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two creeks that had to be diverted. The material was fine sand and clay, together with large boulders. Drifts for the posts were run first, serving also for drainage. The top-heading was then driven, the material being trapped into cars in the bottom heading. The bench was then taken out. The material became harder and more stable when drained. This part of the work was slow and expensive, requiring about eight months.

The rock part of the main tunnel was driven by the 'centre-heading' method. It was 11 ft. wide and 9 ft.

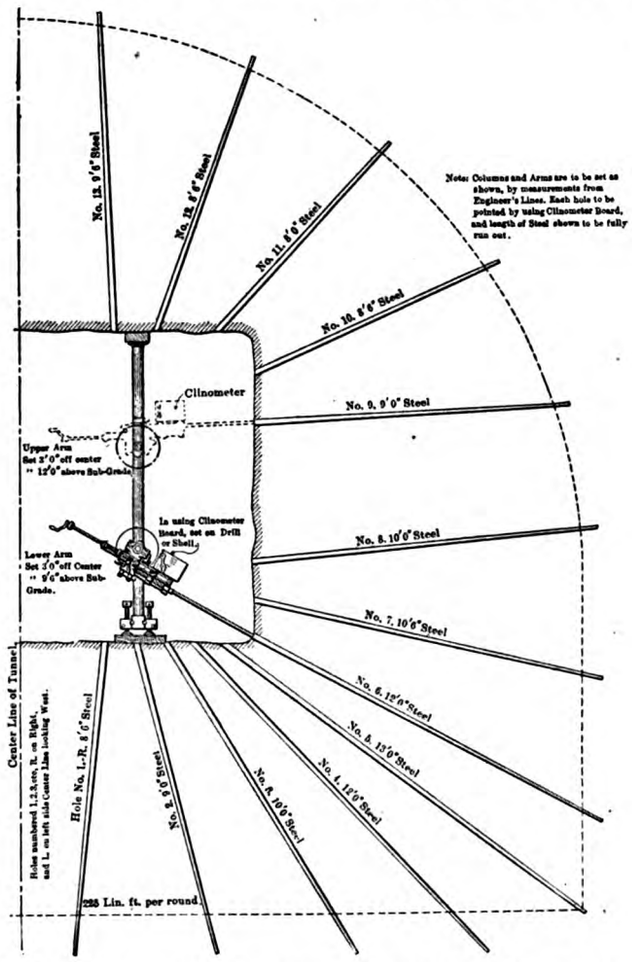

FIG. 4. ARRANGEMENT OF DRILL-HOLES FOR ENLARGEMENT-DRILLING.

high, the centre line being the same as that of the tunnel, and the bottom being 6 ft. above the sub-grade. The air, water, and ventilating-pipes were branches from the mains laid in the pioneer heading. The cross-cuts from the pioneer heading gave access to the main heading. Material from the main heading was handled through the pioneer heading. The main heading was sometimes driven from several faces and usually in a westerly direction, on account of drainage. The system used was similar to that in the pioneer heading. The average daily progress per heading at the east end was 16 ft. and the maximum monthly progress was 621 ft. The corresponding figures for the west end were 20 and 762 ft. A bonus based on the monthly progress and equated for hard rock, was divided among the men directly connected with the tunnel driving in each heading in proportion to the regular wages earned during the month.

The enlargement drilling was done according to the plan shown in Fig. 4. The columns were set by men employed for that purpose so that drillers and helpers had nothing to do but the drilling. The sharpened drill-steel was brought to the drillers and dull steel taken away. A bonus was paid to drillers and helpers, based on the number of feet drilled. Air and water-connections were made for every third ring of holes, and only one drilling-machine, although handled by a different runner on each shift, completed the three rings, and was then moved to the head of the line. This prevented congestion of men and material, and also gave each man a fair chance at the hard and the soft rock. At the commencement of the work the rings were spaced from 6 to $6\frac{1}{2}$ ft. apart, but after the price of explosives rose, the spacing was reduced to 5 ft., as the extra drilling-cost was balanced by the saving in explosives, with the added advantage that the rock was broken into smaller pieces, and scattered farther back in the tunnel. As the air and water for the drilling came from the pioneer tunnel, there was no delay on account of blasting.

The pioneer tunnel was not driven for the last mile, connection being made by the main heading only, which was all drilled for enlargement before the enlargement-blasting reached that part of the work. The main-heading work had to be completed before the enlargement-blasting and shoveling reached the last cross-cut from the pioneer heading, as it would have been impossible to maintain the air-connections, or to ventilate the main heading, so as to permit continuous work. The drilling for the last mile of the enlargement was started at the middle and progressed toward the portal, the track, pipe, etc., being removed as the drilling was finished. The stopping of the pioneer tunnel was well-timed, as the main heading was driven and the enlargement-drilling completed just in time to avoid delaying the enlargement-blasting and shoveling at the east end.

The material in the enlargement was removed with small steam-shovels. The boom-sheaves were set back so as to shorten the boom and protect the sheaves. Some material was usually left at the face of the tunnel, in order to prevent the first ring of holes from scattering the blasted material too far. However, if the material did not break to the required width, all the loose material was loaded, and jack-hammers were used to bring the section to full size. From 10 to 15 rings were usually kept loaded ahead. Several bottom-rings were blasted first, and then top and bottom rings until the pile of loose material was within four or five feet of the roof. Blasting was then discontinued and the roof was trimmed. Where no holes had to be re-loaded, rings could be blasted at intervals of from 15 to 20 minutes. The blasting was done with a battery. In tough rock, from two to eight holes in a ring were sprung.

The ventilating-air was forced into the pioneer tunnel with a Sirocco fan at the portal and through the cross-cut into the main heading ahead of the blasting, thence back to the portal. 'Short-circuiting' of air through

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other cross-cuts was prevented by doors in the cross-cuts. The lineal distance that it was possible to blast at one time without piling the material in the tunnel too high, ranged from 24 to 100 feet.

About 1½ miles of the tunnel, including the soft ground at each end required a concrete lining. This work was sub-let to the Bates & Rogers Construction Co., of Chicago and Spokane. The concrete is reinforced heavily, which prevented the use of the pneumatic method of placing. Wooden forms were used. Most of the lining required back as well as front forms. The space behind the back forms was filled with either rock or wood. The concrete-mixer was mounted on a car. From the mixer the concrete flowed into a small car, which was hauled by cable up a trestle-incline to a platform placed near the roof of the tunnel. From the platform the concrete was shoveled into the forms.

The construction of the tunnel was under the general direction of J. G. Sullivan, chief engineer for the Canadian Pacific Railway. F. F. Busteed, H. G. Barber, and W. A. James were successively in direct charge of the work for the company. A. C. Dennis was superintendent for Foley Bros., Welch & Stewart.

SAFETY-NETS ON STRUCTURAL WORK

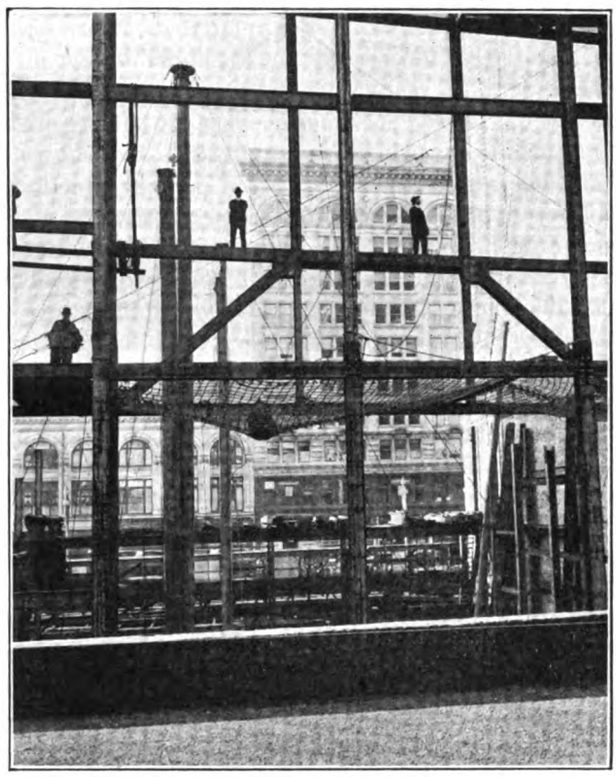
By J. J. ROSENTHAL*

The department of safety of the Industrial Accident Commission of California has found that the State law calling for temporary flooring on each floor for the protection of the men engaged in the erection of steel and iron structures, such as high balconies, galleries, arch-trusses of theatres, auditoriums, churches, armory buildings, railroad train-sheds, towers, viaducts, bridges, domes and cupolas, is in many instances impracticable and involves unnecessary expense. The department, after much investigation and study, has decided that safety-nets will give the men better protection than wooden planking. Accordingly it is ordering the use of these nets on all classes of structural work where planking is impracticable. The nets are similar to those employed by fire departments in some of our large cities to catch persons jumping from burning buildings and to those used for the protection of circus performers.

These nets are inexpensive, easily adjusted, removed, and transported from one job to another. They are suspended beneath points where the men are working and measure 10 by 30 ft. They are made of ½-in. manila rope, with ¾-in. rope in the border and a 4 by 4-in. mesh. The borders are fitted with loops so that the nets can be attached at various points and shifted from one place to another. When the job is completed, the nets are rolled up for storage or shipment.

That these safety nets are practicable is shown by the fact that they have been used successfully for about a year in Chicago. The Department of Factory Inspection of the State of Illinois has a record of a case where, through the use of these nets, a serious accident was avoided. Two painters, working on a high steel truss, lost their hold and fell into the nets without injury to themselves. If these nets had not been stretched below them, both men would have fallen about one hundred feet to a concrete floor.

The accompanying illustration shows the arrangement of four nets, 10 by 30 ft., tied together and used by the Dean Construction Co. of San Francisco, in the erection of the California theatre. This theatre is 100 by 170 ft. by 115 ft. high. It will be the largest moving-picture house west of Chicago. The estimated cost is $500,000. It is a class A building containing 825 tons of structural steel. The four nets cost $60 each. They are the first to be used in construction west of Chicago. The Department of Safety of the Industrial Accident Commission hopes to decrease the serious accidents on steel structures by encouraging the use of this new safety-device.



SAFETY-NETS IN POSITION.

*Safety engineer for the Industrial Accident Commission, 525 Market street, San Francisco.

Oil-land withdrawn from entry on June 30, 1916, had a total area of 5,621,160 acres, 230,400 acres being in Arizona, 1,365,947 in California, 87,474 in Colorado, 467,030 in Louisiana, 641,622 in Montana, 84,894 in North Dakota, 1,952,326 in Utah, and 791,467 in Wyoming. This does not include the shale-oil land withdrawn in December 1916 in Utah, Colorado, and Wyoming. The proportion of patented land in the withdrawn areas is not known. In California it is estimated that about two-thirds of the withdrawn land is patented.

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Highway-Traffic Analysis and Traffic Census Procedure*

By WILLIAM H. CONNELL†

Though the fundamental purpose of a highway is to carry surface-traffic, lack of foresight, largely the result of the absence of studies relative to future traffic has resulted in the case of most municipalities in the general plan of many highways as well as the character of the pavement being inconsistent with the traffic requirements to which the highways are subjected.

The operations constituting the general function of traffic-study may be subdivided into two general classes depending upon the purpose and nature of the data to be obtained and the methods of investigation involved:

Traffic Survey: which has to do with the investigation of the physical and other conditions influencing or relating to the carrying of proposed or existing highway traffic.

Traffic Census: which has to do with investigation of the quantity, character, weights, and other conditions of traffic.

A system of traffic study to be complete and comprehensive should provide sufficient data for consideration of the following features:

The Plan of the Highway: Including the consideration of the use of curved, rectangular or diagonal lines, and of the necessity and position of traffic-circuit highways; the determination of the grade; the number and desirable width of the roadways and footways to accommodate present and probable future traffic requirements; and, the possibility of devoting certain spaces to the purposes of temporary or permanent lawn or planting-areas.

The Design of the Pavement: Including the advisability of improving the full legal width of the roadways and footways, and the selection of the types of pavement surfaces and base-course construction best suited to the requirements of the prevailing traffic.

The Maintenance of the Pavements: Including the study of the depreciation and maintenance costs per unit of traffic and of the physical effects of traffic upon the pavement surfaces with respect to total and unit vehicle-loads, width and character of tires, speed, and non-skidding and braking devices.

The Cleaning of Highways: Including the determination of the kind of cleaning best suited to the existing type of pavement and the prevailing character of traffic and of the hours during which the cleaning may be performed with the least interference or inconvenience to traffic.

Traffic Regulations: Including the assignment of definite highways for specific classes and directions of traffic; the designation of parking areas for automobiles and other vehicles; the establishment of pedestrian crossings and safety islands and zones; the determination of the most suitable position for proposed street-railway tracks and the consideration of the advisability of changing existing tracks; and the establishment of a general system of control by signal devices or otherwise in order to ensure safety and to eliminate entirely or to reduce to a minimum the congestion of both vehicular and pedestrian traffic.

Traffic Units

Like many other engineering determinations, no standard methods have been adopted universally for the classification of traffic, for the taking of traffic-census data, or for the reduction of the census-data to definite units. While most traffic censuses are conducted along the same general principles, yet lack of uniformity in details and especially of a generally recognized standard traffic-unit has limited the value of most traffic-census data mainly to the purposes of local comparison. In most traffic censuses conducted thus far, it has been the general practice to consider as a proper traffic-unit the 'ton of traffic per foot-width of pavement' which is based upon the total load passing over the entire width of the pavement in a measured period of time. This is misleading and practically worthless as a factor to be used in connection with the design of suitable pavement, because in most cases a relatively small portion of the width of a roadway carries most of the traffic while the remainder of the pavement carries comparatively little.

A pavement must be of practically uniform material. This makes it all the more necessary that the selected type of pavement be capable of performing satisfactory service at the point of greatest wear. The segregation of moving traffic is the result of several causes, including the parking of vehicles along the curbs or in the centre of highways and the presence or absence of railway tracks.

It is obvious, therefore, that the width of roadway subjected to moving traffic rarely equals the total width. Usually it will be found to vary between one and two times the average width of the prevailing type of vehicle, and in other cases between one and several times the average width of each of the tire-paths.

In the selection of a satisfactory type of roadway pavement for any given situation, it is also necessary that the annual maintenance and the life-cost, or depreciation and interest on first cost, of the type of

*Condensed from paper presented at the meeting of the American Association for the Advancement of Science, New York, December 28, 1916.

†Chief of Bureau of Highways and Street Cleaning, Philadelphia, Pennsylvania.

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pavement under consideration per unit of traffic be known with some degree of certainty. The most logical and satisfactory unit of traffic-measurement would seem to be the 'ton-mile.' To obtain the actual number of ton-miles, the census figures representing the full load should be reduced proportionately to give the average load.

The use of the 'ton-mile' unit will not alter or render more difficult the general methods employed in the taking of traffic-census data. It is necessary only that the observer be stationed in a block or stretch of highway of known length where every vehicle in passing the observation point must actually traverse a definite fractional part of a mile-length of highway. For the purpose of local comparison, it is seldom necessary to use more than one kind of traffic-unit, but when it is desirable to provide data that may be compared with studies made in similar situations in other communities, any additional units should be used that may be necessary in order that the data may be reduced to comparable form.

Classification of Traffic

Vehicular traffic should be divided into as many classifications as may be necessary to give fairly accurate results. In general, however, fourteen classifications have now become practically the standard. While somewhat arbitrary, they are nevertheless considered to be fairly representative. These classifications are as follows:

Classification:		Average weight in short tons
Horse-drawn		
a	Horse without vehicle	0.65
b	Light vehicle drawn by one horse	1.20
c	Heavy vehicle drawn by one horse	2.00
d	Light vehicle, drawn by two horses	2.00
e	Heavy vehicle drawn by two horses	4.00
f	Vehicle drawn by three horses	5.00
g	Vehicle drawn by four horses	6.00
Motor-driven		
h	Motorcycle or bicycle	0.15
i	Motor vehicle, two passenger	1.30
j	Motor vehicle, over two passenger	2.20
k	Light motor truck	3.30
l	Medium motor truck	6.00
m	Heavy motor truck	8.50
Miscellaneous		
n	Miscellaneous extra-heavy traffic	As estimated

The terms 'light,' 'medium,' and 'heavy' as used in these traffic classifications are intended to indicate the greatest capacity of the vehicle and not the relative weight of the load carried at the time of its observation. These classifications of traffic are intended to serve for general purposes only. In determining the probable compressive, shearing, and impact stresses produced in the pavement it will also be necessary to determine the maximum unit-weights carried per inch of effective width of tire. In this connection it should be noted that tires in general use include both metal tires, smooth-surfaced and non-skidding rubber tires of both the solid and inflated types, also caterpillar solid-rubber tires and tires equipped with non-skidding devices.

Analysis of Traffic-Census Data

The data compiled from a systematic census taken each year and representative of average traffic conditions prevailing throughout the year make it possible to estimate closely the probable total tonnage carried during the year. These data when considered in conjunction with the records of the total annual charges for depreciation and interest on first cost, and maintenance costs, together with the average traveled-widths of the pavements will give the following information:

Traffic Tonnage

(*a*) Total tons of traffic per year carried by the highway.
(*b*) Average tons of traffic per year per foot-width of roadway pavement.
(*c*) Average tons of traffic per year per foot of maximum traveled-width of roadway pavement.
(*d*) Total tonnage for life of pavement per foot-width of roadway.
(*e*) Total tonnage for life of pavement per foot of maximum traveled-width.

Ton-Mile Maintenance-Costs

(*f*) Annual charges for depreciation and maintenance-cost per ton-mile of traffic.
(*g*) Total charges for depreciation and maintenance-cost per ton-mile for life of pavement.
(*h*) Average ton-miles of traffic per unit charge for average annual cost of pavement.

This tabulation will show definitely the relation between the traffic-service and the depreciation and the maintenance-costs of the pavement. This is an important factor to be considered in the selection of a type of pavement.

Annual Cost of Pavements

The accompanying table has been compiled to give a general idea of the relative first cost of the different types of pavements, and the cost per square yard per year, based upon interest and sinking-fund charges plus maintenance for bond issues maturing in 10, 30, and 50 years, serial bonds, and also bonds for a time equal to the estimated economic life of the base and surface-course respectively for the different types of pavements, and the mathematical-mean economic life.

Column *A* indicates character of pavement. Only the more extensively used types have been considered. Each pavement has been divided into base and surface-course.

Column *B* indicates estimated first cost. These costs are based on average unit prices for several years past. Allowances should be made for local variations in cost of labor and material.

Column *C* indicates estimated economic life. This is based on assumed life of the base and surface-course for the traffic conditions for which each type is best suited.

Column *D* indicates mathematical-mean economic life.

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City Street Pavements

A.	B	C	D.	E.	F	G.	H.	I.	J	K.
Sheet Asphalt:	$			$	$	$	$	$	$	$
6-In. Concrete-base course	0.85	40	23	0.03	0.2231	0.1740	0.1324	0.1592	0.1506	0.1579
1½-In. Surface and 1-In. Binder-course.	1.05	17								
Vitrified Block:										
6-In. Concrete-base course	0.85	40	19	0.04	0.3688	0.2851	0.2129	0.2448	0.2325	0.2417
4-In. Surface and 1-In. Sand-cushion course	1.80	15								
Granite Block:										
6-In. Concrete-base course.	0.85	40	36	0.005	0.2181	0.1603	0.1012	0.1748	0.1555	0.1732
5½-In. Surface and 1-In. Sand-cushion course	2.60	34								
Wood Block:										
6-In. Concrete-base course.	0.85	40	24	0.03	0.3296	0.2534	0.1887	0.2311	0.2150	0.2267
4-In. Surface and 1-In. 1:4 Cement-mortar cushion.	2.15	20								
Asphalt Block:										
6-In. Cement-concrete base-course	0.85	40	18	0.06	0.3755	0.2951	0.2271	0.2544	0.2452	0.2535
3-In. Asphalt-block surface, and										
2-In. 1:4 Cement-mortar cushion.	1.60	14								
Bituminous:										
6-In. Concrete-base course.	0.85	40	20	0.05	0.2574	0.2046	0.1598	0.1828	0.1760	0.1824
1½-In. Surface and 1-In. binder.	0.95	14								
Bituminous.										
6-In. Concrete-base course.	0.85	40	17	0.05	0.2624	0.2083	0.1625	0.1792	0.1722	0.1774
2-In. Surface course	0.70	10								

Suburban And County Roads

A	B	C	D.	E.	F	G	H	I	J	K
Bituminous:	$			$	$	$	$	$	$	$
5-In. Concrete-base course.	0.70	40	26	0.03	0.1813	0.1428	0.1102	0.1353	0.1265	0.1332
1½ In. Surface and 1-In. binder.	0.95	20								
Bituminous:										
5-In. Concrete-base course	0.70	40	22	0.04	0.1893	0.1514	0.1190	0.1384	0.1316	0.1369
2-In. Surface course	0.70	15								
Bituminous:										
6-In. Broken-stone base.	0.60	20	15	0.04	0.2456	0.1932	0.1489	0.1588	0.1527	0.1569
2-In. Surface course.	0.70	12								
Bituminous.										
3-In. Broken-stone	0.60	20	14	0.04	0.2495	0.1961	0.1510	0.1581	0.1497	0.1536
3-In. Penetration surface	0.60	10								
Concrete, Reinforced.										
6-In. Concrete course.	1.45	20	20	0.04	0.2087	0.1658	0.1294	0.1467	0.1415	0.1467
Waterbound Macadam:										
8-In. Telford base-course	0.50	30	15	0.06	0.2152	0.1756	0.1421	0.1505	0.1468	0.1499
4-In. Broken trap-rock surface course,										
bituminous surface treated	0.50	10								
Waterbound Macadam:										
4-In. Broken-stone course	0.50	20	14	0.06	0.2346	0.1901	0.1524	0.1584	0.1514	0.1547
4-In. Broken trap-rock surface course,										
bituminous surface treated	0.50	10								

TABLE I. COST DATA ON PAVEMENTS.

These figures were derived by the following method. If the annual sinking-fund charges for the base and surface-course are added together, this sum, taken as an annual sinking-fund charge, will, at the end of the given period accumulate an amount equal to the total unit cost of the pavement.

Column *E* indicates annual maintenance-costs, including such repairs as are necessitated by service-wear and also the application of bituminous surface-treatments in the case of water-bound macadam pavements.

Columns *F*, *G*, and *H*, respectively, give total annual sinking-fund, interest, and maintenance-charges for 10, 30, and 50-year bonds, pro-rated over the economic life of the pavement.

Column *I* indicates annual charges, including sinking-fund and interest charges on two bonds extending over the estimated economic life of the base and surface-course, plus maintenance-charges.

Column *J* indicates annual cost under serial bonds, including the annual proportional part of the original loan-fund, extending for a period equal to the mathematical-mean economic life of the pavement, which is redeemed each year by installment payments, plus the interest on the unpaid balance of the loan-fund, plus the annual maintenance-costs.

Column *K* indicates total annual sinking-fund, interest, and maintenance-charges when bonds are issued for period equal to the mathematical-mean economic life of the pavement.

The economic life of the concrete foundation-courses has been based on depreciation resulting from openings and other causes. In the case of granite-block pavements, a salvage value of $0.50 per sq. yd. for the old blocks has been pro-rated over the economic life of the pavement and deducted from the annual costs. Ten-year bonds, while less costly to the city than bonds

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running for the economic life of the pavement, are more costly to the tax-payer.

The consideration of the mathematical-mean economic life of the base and surface-course was deemed desirable for purposes of general discussion relative to the economic life of pavements and their costs. The figures indicated in column *D* of the table represent the mathematical-mean economic life of each respective type of pavement based upon the estimated economic lives and the relative costs of the base and surface-course. The maintenance-cost and the estimated economic life given in the table are only approximate. They are based upon average conditions and are not intended to represent definite data applicable to any city or locality.

The actual maintenance-cost of pavements cannot be determined for 10 or 15 years, or until some of the maintenance-cost records now being kept in a number of localities have extended over a period of years equal to the actual economic life of the several types of pavement. In the meantime certain assumptions will have to be made, based upon scientific research and the experience and judgment of qualified experts. It should be borne in mind, however, that a similar procedure was necessary in the infancy of life-insurance companies and other undertakings dependent upon knowledge of probable future conditions concerning which no reliable data were available.

Of course, the fact that each of these different types of pavements is usually constructed to meet specific traffic conditions should be taken into consideration. For instance, a granite-block pavement on a concrete base, costing \$0.1732 per sq. yd. per year would be constructed upon a heavy-traffic street, whereas a bituminous pavement on a broken-stone base costing \$0.1569 per sq. yd. per year would be used on a suburban or country road carrying comparatively light traffic. Similarly, the concrete and bituminous types of pavement, while they may show a higher annual cost than water-bound macadam, are figured for traffic conditions where water-bound macadam would not be suitable.

It is estimated that there are a number of heavy-traffic streets in the business sections of such cities as New York, Chicago, Philadelphia, and Boston, where a granite blocks at the expiration of the economic life of the pavement.

Traffic-Census Procedure

In all kinds of traffic studies, irrespective of their specific purpose, a definite traffic-census procedure is of fundamental importance. This is equally true whether the subject of the study is an existing or a proposed highway. Of course, when an existing highway is under consideration it will be nearly always possible to collect traffic-census data directly. In the case of a proposed highway, however, the traffic-census data would necessarily have to be taken on a highway upon which the general conditions would be assumed to be analogous to the conditions that would probably exist on the proposed highway.

Selection of Observation-Points and Frequency of Observation

Observation-points should be carefully selected. A sufficient number of points should be used to represent the characteristic traffic-requirements on each general class of highway and on the several kinds of pavement in general use.

It is desirable that four counts should be taken each year, one count being made during each of the four seasons. Each count should be taken continuously between the hours of 5 a.m. and 9 p.m., or else during the entire 24 hours if so desired, in either case on a consecutive Friday, Saturday, Sunday, and Monday, in this way including two full business days, a half-holiday and a whole holiday. In this connection it is important to note that while city streets carry the most traffic on business days, suburban and country roads carry their maximum traffic on Sundays and holidays.

The observers should ordinarily be on duty in two 8-hour shifts, working respectively from 5 a.m. to 1 p.m. and from 1 p.m. to 9 p.m. Under ordinary conditions, one observer should be stationed at each observation-point. If, however, the volume of traffic or the number or extent of the details to be noted require that two or more observers be assigned, each observer should record data regarding the traffic going in one direction.

Traffic-Observation

To provide for the systematic collection of traffic-

TABLE II.

COMPARISON OF ANNUAL COST DATA PER SQUARE YARD FOR SHEET-ASPHALT AND GRANITE-BLOCK PAVEMENTS SUBJECTED TO SIMILAR TRAFFIC CONDITIONS

Character of pavement	Estimated economic life in years		Estimated first cost		Maintenance	Interest and sinking-fund charges	Total annual cost
	Base	Surface	Base	Surface			
Sheet asphalt	40	7	\$0.85	\$1.05	\$0.06	\$0.2178	\$0.2778
Granite block	40	17	0.85	2.60	0.03	0.2566	0.2572

sheet-asphalt pavement would last not more than 7 years, while a granite-block pavement would last 17 years.

The total annual cost of granite-block pavement as indicated in the preceding table includes a deduction of \$0.0294, which is based on the salvage value of the old

data the following forms should be provided:

(*a*) Traffic-condition survey-reports.
(*b*) Traffic-census observation-reports, one form for each of the several observation periods.
(*c*) Traffic-census observation-report summary-form.
(*d*) Traffic-census data-compilation reports.

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BUREAU OF HIGHWAYS
DEPARTMENT OF PUBLIC WORKS
CITY OF PHILADELPHIA

TRAFFIC CONDITIONS SURVEY REPORT

FROM TO

OBSERVATION POINT: SERIAL NUMBER LOCATION

LENGTH OF HIGHWAY DOMINATED BY THIS OBSERVATION POINT

	NUMBER	WIDTH	PAVEMENT WIDTH	PAVEMENT SURFACE	PAVEMENT BASE	TRAVELLED WIDTH OF PAVEMENT
ROADWAYS						
FOOTWAYS						

	NUMBER	LOCATION	
RAILWAY TRACKS			DIRECTION OF TRAFFIC
VEHICLE PARKING AREAS			WIDTH
LAWN AND PLANTING AREAS			WIDTH

GENERAL DIRECTION OF VEHICULAR TRAFFIC | OBSERVER | DATE 191

(PLAN AND SECTION OF HIGHWAY AND CONDITIONS AT OBSERVATION POINT)

FIG. 1. TRAFFIC-CONDITIONS REPORT.

For each point at which observations are to be made there should also be a traffic-condition survey and the results noted on the report (Fig. 1). This should include the following information:

(*a*) Name and limits of highway.
(*b*) Serial number and position of observation-point.
(*c*) Length of highway visible from observation-point.
(*d*) Number, position, and widths of paved and unpaved roadways and footways.
(*e*) Character of surface and base, of roadway-pavement and of footway-pavement surface.
(*f*) Traveled widths of roadway and footway pavements.
(*g*) Presence or absence and number and position of railway tracks.
(*h*) Direction of railway traffic.
(*i*) Number, width, and general position of vehicle-parking areas.
(*j*) Number, position, width, and character of lawn or planting-areas.
(*k*) General direction of vehicular traffic.
(*l*) Date of observation.
(*m*) Names of observers.

BUREAU OF HIGHWAYS
DEPARTMENT OF PUBLIC WORKS
PHILADELPHIA

TRAFFIC CENSUS OBSERVATION REPORT

FROM TO

OBSERVATION: DATE DAY PERIOD: 5 A. M. TO 1 P. M.

OBSERVATION POINT: SERIAL NUMBER LOCATION

WEATHER CONDITIONS:

NAMES OF OBSERVERS:

CONDITION OF PAVEMENT: CLEAN DIRTY DAMP DRY SLIPPERY SAFE

CLASSIFICATION OF TRAFFIC			HOURS OF OBSERVATION 5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–1	TOTAL
HORSE											
HORSE-DRAWN	1-HORSE VEHICLE	LIGHT									
		HEAVY									
	2-HORSE VEHICLE	LIGHT									
		HEAVY									
	3-HORSE VEHICLE										
	4-HORSE VEHICLE										
	MISCELLANEOUS HEAVY										
	TOTAL										
MOTOR-DRIVEN	MOTOR-CYCLE (OR BICYCLE)										
	PASSENGER	2									
		3 AND OVER									
	FREIGHT	LIGHT									
		MEDIUM									
		HEAVY									
	MISCELLANEOUS HEAVY										
	TOTAL										
ACCIDENTS	HORSE FALLS										
	MOTOR VEHICLE SKIDS										
	TOTAL										

FIG. 2. TRAFFIC-CENSUS REPORT.

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BUREAU OF HIGHWAYS DEPARTMENT OF PUBLIC WORKS CITY OF PHILADELPHIA	TRAFFIC CENSUS OBSERVATION REPORT SUMMARY	FROM TO OBSERVATION POINT SERIAL NUMBER LOCATION

	CLASSIFICATION OF TRAFFIC		FRIDAY	SATURDAY	SUNDAY	MONDAY	TOTAL	REMARKS
HORSE-DRAWN	HORSE							
	1-HORSE VEHICLE	LIGHT						
		HEAVY						
	2-HORSE VEHICLE	LIGHT						
		HEAVY						
	3-HORSE VEHICLE							
	4-HORSE VEHICLE							
	MISCELLANEOUS HEAVY							
	TOTAL							
MOTOR-DRIVEN	MOTOR CYCLE (OR BICYCLE)							
	PASSENGER	2						
		3 AND OVER						
	FREIGHT	LIGHT						
		MEDIUM						
		HEAVY						
	MISCELLANEOUS HEAVY							
	TOTAL							
ACCIDENTS	HORSE FALLS							
	MOTOR VEHICLE SKIDS							
	TOTAL							

FIG. 3. TRAFFIC-CENSUS SUMMARY.

During the census-taking operations each observer should indicate on the traffic-census observation-report (Fig. 2) the following data:

Fixed Conditions:

(*a*) Name and limits of highway.
(*b*) Serial number and position of observation-point.
(*c*) General condition of pavement as regards repair.

Variable Conditions:

(*d*) Date of observation.
(*e*) Observation-period.
(*f*) Number and names of observers.
(*g*) Weather conditions.
(*h*) General condition of pavement with regard to cleanliness, dryness, and slipperiness.

Traffic Conditions:

(*i*) Number of units of each class of traffic passing the point of observation during each hour.
(*j*) Number of complete or partial falls of horses and skidding of motor vehicles.

BUREAU OF HIGHWAYS DEPARTMENT OF PUBLIC WORKS CITY OF PHILADELPHIA	TRAFFIC CENSUS DATA COMPILATION RECORD	FROM TO OBSERVATION POINT: SERIAL NUMBER LOCATION

DATE OF OBSERVATION	CHARACTER OF TRAFFIC DAY	WEATHER CONDITIONS	VEHICLE DATA										TONNAGE DATA									
			TOTAL PER DAY			AVERAGE PER HOUR			MAXIMUM HOUR		AVERAGE PER MINUTE PER FOOT WIDTH OF PAVEMENT		TOTAL PER DAY			AVERAGE PER VEHICLE			AVERAGE PER MINUTE PER FOOT WIDTH OF PAVEMENT		PERCENTAGES OF TRAFFIC	
			HORSE	MOTOR	TOTAL	HORSE	MOTOR	TOTAL	NUMBER	HOUR	TRAVELLED WIDTH	TOTAL WIDTH	HORSE	MOTOR	TOTAL	HORSE	MOTOR	TOTAL	TRAVELLED WIDTH	TOTAL WIDTH	HORSE	MOTOR

FIG. 4. TRAFFIC-CENSUS RECORD.

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(*k*) Total number of units under items (*i*) and (*j*) for each hour and for the entire observation-period.

The data required under 'Traffic Conditions' should be recorded for each hour of the observation-period.

In certain investigations made in conjunction with traffic-regulation or planning studies, it may be necessary to observe also the quantity of pedestrian traffic on the footways and at the crossings, or to obtain certain other special data. In such cases, it will be necessary to use special forms on which to collect and compile this information.

The observation-reports for each day should be mailed to the main office at the close of the observer's period of duty. They should be summarized on the traffic-census observation-report summary (Fig. 3) which is simply a compilation of the data contained in the several observation-reports for the entire four day's observations at a specific observation-point.

Compilation of Traffic-Census Data

For each length of highway on which a traffic-census is taken a traffic-census data compilation-report (Fig. 4) should be originated to serve as a permanent and complete record of all the data that may be collected for the particular stretch of highway. On this report there should be recorded from the observation-report and summary forms the following data:

Fixed Conditions:

(*a*) Name and limits of highway.
(*b*) Serial number and position of observation-point.

Variable Conditions:

(*c*) Date of observation.
(*d*) Character of traffic day.
(*e*) Weather conditions.

Traffic Data, Vehicles:

(*f*) Horse-drawn, motor-driven, and total traffic per day.
(*g*) Average horse-drawn, motor-driven, and total traffic per day.
(*h*) Maximum hour; quantity and hour designated.
(*i*) Average traffic per minute per foot-width of paved roadway.
(*j*) Average traffic per minute per foot of maximum traveled-width of roadway pavement.

Traffic Data, Tonnage:

(*k*) Horse-drawn motor-driven, and total traffic per hour.
(*l*) Horse-drawn, motor-driven, and total traffic per day.
(*m*) Average traffic per minute per foot-width of paved roadway.
(*n*) Average traffic per minute per foot of maximum traveled-width of paved roadway.
(*o*) Percentages of horse-drawn and motor-driven traffic.

CONCRETE ROAD TESTS

The United States Office of Public Roads and Rural Engineering has begun a series of tests at Arlington, Virginia, to determine the proper thickness of the concrete base for roads of different types when subjected to loads of different magnitude and when placed on various kinds of sub-base, according to a bulletin issued recently by the Department of Agriculture. In view of the increasing intensity of wheel loads to which roads are now being subjected, the solution of this problem is becoming of great economic importance.

Steps have been taken to mold slabs of varying thicknesses on several kinds of sub-base and test them to destruction, the load being applied through various kinds of paving surface. Concrete roads are now being built throughout the country with numerous kinds of aggregate and under various construction methods. There is a noticeable difference in the amount of wear experienced by these surfaces, and it is uncertain which kind of aggregate will prove most economical under particular conditions of traffic and location of source of supply.

In order to gain information of value in this connection, an instrument has been constructed for the purpose of measuring the amount of wear of concrete roads of different types. Periodical wear-measurements will be taken of concrete road surfaces on which the traffic conditions are known. It had long been known that concrete is not elastic, but attains permanent deformation under working loads. During a series of tests on reinforced concrete slabs now being made by the Office of Public Roads and Rural Engineering, it was brought forcibly to the notice of the observers that the concrete continued to deform slowly as long as the load was applied. This fact is significant, as it helps to explain certain stress conditions in concrete roads and bridges when subjected to temperature changes.

In order to study this phenomenon more fully, a series of tests has been begun to determine the 'flow' of concrete and reinforced concrete when subjected to direct compression and to bending stresses. Working conditions will be maintained on the specimens as long as they exhibit 'flow,' and finally the specimens that have not been loaded previously.

Silting in the Elephant Butte reservoir has been investigated by the U. S. Reclamation Service. The investigations indicate that the average annual inflow of silt based on the records from 1897 to 1912, is 11,336 acre-feet. The total available capacity of the reservoir is 2,638,860 acre-feet, indicating a life of 233 years. Even after the reservoir had become filled with silt, there would be considerable available storage, since the silt contains 44% voids.

The greatest number of accidents occur at 10 a.m. and at 3 p.m., according to studies made by the Bureau of Safety.

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Problems Connected With the Recovery of Petroleum From Unconsolidated Sands*

By WILLIAM H. KOBBE†

Finishing a Well in Unconsolidated Sands. The process of finishing a well in an unconsolidated sand is different from the case of a well tapping a hard sand. It sometimes requires weeks to penetrate a thick stratum of loose sand using cable tools, while the 'drilling in' and 'shooting' of a hard sand is a much simpler process. Where the sand, whether loose or hard, is under great pressure and the well 'comes in' as a gusher or flowing well as soon as the sand is tapped, the results are similar except that the well in the unconsolidated stratum is likely to throw out great quantities of sand.

The ideal method of finishing a well through a thick stratum of loose sand is the rotary system. A rotary often penetrates 300 ft. of unconsolidated sand in 12 hours or less. By thickening the circulating-mud the pressures may be balanced to such a nicety that upon reaching the stratum underlying the sand the drill-pipe may be withdrawn without danger of caving. This is because a column of mud-laden fluid extends through the sand and is substituted in the physical balance of forces for the loose sand that previously occupied the same space. Although all the purposes of an open hole have been served, nature's balance is left undisturbed. This mud may be allowed to stand for several hours, but the best practice is to prepare the liner or perforated casing in advance and have everything ready for casing the well immediately upon withdrawal of the drill-stem. The liner may consist either of shop-perforated casing or one of the several types of screen-pipe which have come into use because of their efficiency in handling sand and thereby increasing the amount of oil recovered.

It will be assumed that screen-pipe is to be set and that the water-string consists of 8¼-in. casing landed in a hard stratum a few feet above the oil sand. Three hundred feet of 6⅝-in. screen pipe is carefully tallied and two blank joints of the same size made ready. A collar is screwed on the bottom of the last joint of screen-pipe and a back-pressure valve and wooden wash-plug placed therein. The 300 ft. of screen-pipe with the two blank joints on top is then run into the hole to bottom on 3-in. tubing, this tubing resting on the wooden wash-plug and being attached to the 6⅝-in. casing with a right and left-thread nipple. The principal thing is to have the tubing extend through the screen-pipe in order that the water may pass out of the bottom of the liner and not through the meshes of the screen. When the liner has reached bottom it is raised an inch or two, and the well is washed thoroughly by pumping clear water through the tubing or wash-pipe for 24 hours, or until the 'returns' cease to show any trace of mud. The wash-pipe is then backed off by turning to the right, and is withdrawn. This leaves the liner clean, with no mud between the meshes, and the oil sand and the two joints of blank 6⅝-in. casing extending up into the 8¼-in. casing, forming a 40-ft. lap. An adapter from 6⅝ in. to 8¼ in. is then lowered on the bailer or dropped through the water in the casing until it rests on top of the liner, making a smooth connection between it and the 8¼-in. casing. The well is then tubed and, upon the water pressure being relieved, begins to produce oil.

The proper setting of screen-pipe with a rotary requires experience and knowledge, especially as quick work is desirable and any accident may prove costly. Instead of using tubing, a heavy liner, whether of screen pipe or perforated casing, may be set with the rotary drill-pipe, as the same method is used with both.

The finishing of a well with cable tools in a thick stratum of unconsolidated sand is more difficult than where a rotary is used. The ordinary procedure, especially in districts where screen pipe has never been tried or is unknown, is to carry the finishing-string of casing through the oil-sand and then perforate it. It frequently happens that the string 'freezes' after penetrating the sand for 100 ft. or less, in which event it is customary to place an iron or wooden heaving-plug in the bottom of the casing and then perforate. If the operator is fortunate enough to carry the casing through the sand it can be landed in the underlying stratum, which dispenses with a heaving-plug, the only function of which is to prevent the sand heaving inside the casing and burying the pump. Irrespective of the depth of sand attained, the use of the perforator is necessary with this method. This is its greatest drawback, mainly on account of the uncertainty of the results. For mechanical reasons, variation in the thickness or toughness of the casing, and other factors beyond the control of the operator, the result of the use of a perforating-machine is frequently disappointing. If the well becomes a small producer there is always the suspicion that the perforator failed to make a sufficient number of holes, whereas if the casing 'sands up' and the well requires constant 'pulling' the reverse is true.

*From paper presented at the meeting of the American Institute of Mining Engineers, February 1917.

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In the light of these facts and of past experience in drilling many wells in unconsolidated oil-sands, it may be said that every effort should be made to avoid bringing in the well by perforating the casing after it has been placed in the hole. As a substitute for such perforating the operator may use screen-pipe or shop-perforated casing. In finishing a cable-tool well with either of these two devices the problems involved are largely or entirely dependent upon the thickness of the unconsolidated sand. If this sand is a thin bed 50 ft. or less in thickness there is usually no difficulty in setting any type of screen-pipe or of shop-perforated casing, but where the sand is 250 to 300 ft. thick, many obstacles may be encountered. The ideal method of finishing a cable-tool well in a thick stratum of loose sand is to carry, say, 8¼-in. casing through the sand and then set a 6⅝-in. liner, either screen or shop-perforated, preferably the former, inside the 8¼-in. string and then remove the 8¼-in. casing, leaving the liner in contact with the oil-sands. This is difficult to accomplish, however, because it necessitates keeping the 8¼-in. string free at all times, and this is seldom possible. In fact, it may 'freeze' beyond all power of loosening while the liner is being set.

It well may be asked, why not carry 8¼-in. screen-pipe or shop-perforated pipe through the sand in the first place and thus save the extra labor of setting a liner and gain the advantage of completing a well of larger diameter? The answer is that it is much more difficult to carry perforated than blank casing through unconsolidated sands. In addition, certain screens are not made to withstand such work and are easily damaged, necessitating the use of a conductor-casing when setting.

Screen-casing may be divided into two general classes: (*a*) where the screening-device is on the outside of the casing (Fig. 1); and (*b*) where the screen forms a part of the casing-wall (Fig. 2). In the first type the screen generally consists of wire wound around perforated casing, while in the second type the screen is in the form of numerous buttons or slotted brass plugs carried in the walls of the casing and flush with the outside surface, or in slits cut directly in the casing-wall itself. This latter type, sometimes known as 'wireless' screen, has the advantage of withstanding hard usage. Many operators have carried it for considerable distances through unconsolidated sands. But in thick strata of loose sand, it is as difficult to carry as shop-perforated casing and cannot be used at all where blank pipe encounters difficulties. The wire-wound screen-casings are not adapted for going through thick strata of unconsolidated sands. Attempts to finish a well in that way should not be made. The wire screen possesses many advantages over the wireless, as will appear later, but in finishing a well with this type of screen it is necessary to set it either inside a conductor-string or by means of a rotary. Otherwise the wires may become detached from the casing and cause endless complications and trouble.

Extracting the Oil and Sand. The process of obtaining oil when it is contained in a loose unconsolidated sand is different from that employed to extract the recoverable portion of the oil content of a hard stratum. With an unconsolidated sand the extraction of its oil content may take place above ground whereas with a hard oil-bearing stratum this is impossible. This distinction has an important bearing upon all questions relating to oil production. It is the factor deserving the greatest consideration in determining the efficiency of methods employed for the maximum recovery of oil from unconsolidated sands and is the basic principle underlying the fact that, other things being equal, the maximum recovery of oil from an unconsolidated sand is directly dependent upon the maximum recovery of the sand itself.

This law is based upon two important considerations: (1) The removal of sand by a well causes a larger volume of sand, and therefore of oil, to move toward that well than would be the case if oil only were removed. (2) The most efficient separation of sand and oil, and therefore a nearer approach to obtaining the recoverable oil-content, is made when this separation takes place above ground.

The Movement of Sand and Oil Toward a Well. The higher the viscosity and the lower the gas pressure within the oil reservoir the greater becomes the importance of creating and maintaining a movement of sand toward a producing well. This has been proved beyond all question in extensive operations in the North Midway district of California where the oil is of 14.5° gravity and the gas-pressure is low.

"In the Balakhany oil district, where the oil is heavy, and the gas has nearly all escaped from innumerable wells, the concentration of the petroleum toward old producing areas is very marked, and whilst old bailing properties, which have for many years yielded a moderate payable production show little or no fall-off, new lands interspersed between these are almost valueless and give practically no output when wells are sunk. This is additional testimony of the movement of oil toward spots where immense quantities of sand have been removed by bailing, creating areas of low density into which the petroleum, no longer assisted by a gas pressure, percolates by gravitation. In one case, a new well bored in the Balakhany district was a distinct failure, for stratum after stratum failed to yield even a mean production, but an old well which had been bailed for many years before abandonment, gave, when cleaned out, the extraordinary production of 2500 poods[1] a day for more than a month, and then only fell off by degrees to 400 poods daily."[2]

The fact that large producers are completed without 'making sand' shows the existence of high gas-pressure and insufficient means of entry for the sand to pass into the casing, but it is not proof that the large production is due to the absence of sand or that the out-

[1] About 300 barrels.

[2] A. B. Thompson. 'The Oil Fields of Russia,' p. 51.

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put would not be increased if sand were expelled with the oil. With proper mechanical arrangements a well tapping a thick stratum of unconsolidated oil-sand produces a large amount of sand. That it continues to do this for long periods is proof that a constant replenishment takes place near the casing, necessitating a movement of sand and oil toward the well. This movement is frequently of such volume, or occurs so suddenly, that the casing penetrating the reservoir is damaged or completely severed from the upper and more rigid portion of the string. In one case 250 ft. of 36-lb. 8¼-in. casing was twisted somewhat in the shape of the letter 'S' and was removed from the well with great difficulty. In another instance several hundred feet of 6¼-in. 20-lb. casing was broken just below the collar and displaced to such an extent that no part of it was touched by the tools while repairing the damage. No type of casing is proof against this force of moving sand. Both screen and perforated pipe suffer, although it is believed the former is damaged less than the latter. Likewise it appears to make but little difference whether the casing passes entirely through the sand and is anchored in an underlying stratum or penetrates for only half the distance.

Methods of Extraction. In order to bring about a movement of sand with its oil-content toward the well, it is necessary to provide means for its efficient removal with special casing devised to facilitate this process. If the sand cannot enter the casing, not only is the movement of oil retarded, but the sand surrounding the casing is partly drained of its oil-content, resulting in a constantly increasing body of 'dead' sand opposed to the richer portions of the reservoir. Instances are known where a well, because of faulty perforations or inadequate screen-openings, produced small quantities of clean oil free from sand for several years. When an attempt was made to substitute screen with proper-size mesh the sand had become so 'dead' in the vicinity of the well that it lacked the 'life' to enter the casing and continued to obstruct the path of richer sand. The same conditions apparently explain similar failures when a well was re-perforated, but in such a case there is the element of doubt that arises whenever a perforating-machine is used. These cases occurred with a loose oil-sand containing an asphaltic crude-oil of 14.5° gravity. These wells were undoubtedly influenced by nearby wells having established strong drainage channels. In any event the fact remains that they produced no sand and little oil and that these conditions could not be improved. Furthermore, there was no local variation in the reservoir or other controlling factors.

On the other hand, when a well is equipped properly and produces great quantities of sand with the oil, a large area of lower density is gradually established around the casing. Unless encroaching water is present in quantity, this removal of sand must inevitably lead to the formation of a cavity. This cavity probably assumes the form of an inverted cone as sand continues to be removed while new sand with its oil flows down the slopes of this subterranean funnel and supplies the well with fresh material. The shape of the cavity is influenced by the dip of the strata, when this is marked, and also by the disturbing effect of nearby wells. That a cavity forms, however, cannot be disputed. Sand slips, damaged casing, and collapse of the cover-rock are evidence of such a cavity as well as the impossibility of otherwise explaining the effect of removing the tremendous volume of sand that wells have been known to produce.

It would be interesting to know when the slopes of these cavities reach an angle of repose. Experiments with saturated oil-sand on the surface should prove instructive. The fact that wells producing from unconsolidated sands gradually diminish in their output of sand may indicate the approaching stability of these underground slopes, and evidence presented in later paragraphs strengthens such belief.

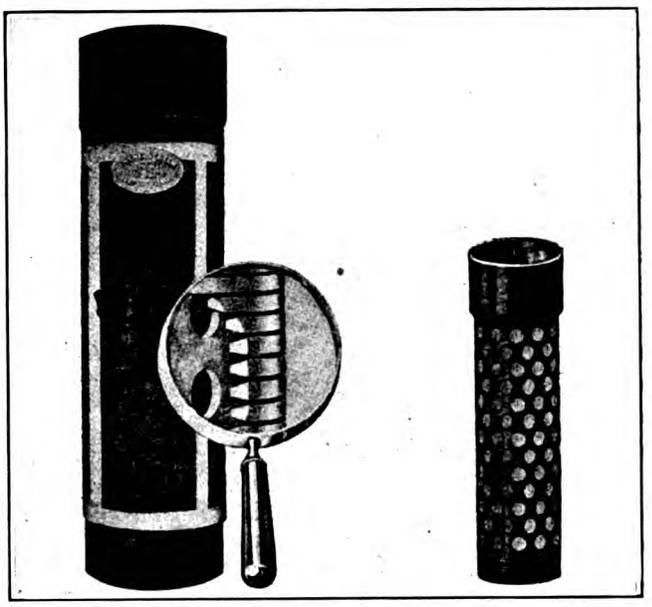

FIG. 1 AND 2. WIRE-WOUND AND WIRELESS SCREEN-CASING.
(Photographs from Layne & Bowler Corporation and McEvoy Wireless Well Strainer Company.)

Function of Screen-Casing. Screen-casing of proper mesh serves its best usefulness in permitting the regulated entry of the maximum amount of sand and oil while excluding gravel and small stones which would 'sand up' the pump by 'sticking' the valves or otherwise preventing its proper action. It probably serves another use in that it results in a more even distribution of the oil and sand channels radiating from the well than is the case with ordinary perforations. This even drainage of sand and oil equalizes the pressure in all directions around the casing, whereas the use of a perforating-machine may result in the sand being drained from one side more than the other, thus creating a pressure against the casing. This unequal drainage, due to faulty perforation, is an argument for the use of screen-pipe and a possible explanation of deflection and damage to oil-strings.

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A section of wire-wound screen-casing is shown in Fig. 1. This type of screen utilizes 'keystone wires' whose function is to prevent clogging of the mesh, the space between the wires increasing radially and thus permitting any substance that enters to pass through unhindered. A large screening surface is exposed to the sand with this type, since the wires between the perforations are utilized as fully as those directly over the openings. Fig. 2 shows a section of wireless or button-screen which is especially adapted for work with cable tools, as it will withstand hard usage and the driving and pulling often necessary with that system in drilling through unconsolidated sands.

The selection of the proper-size mesh depends upon the physical character of the sand, viscosity of the oil, and the gas-pressure. The mesh should be of sufficient size to allow the maximum entry of sand and oil while excluding pebbles and small stones. This is best determined by practical experiments above ground. Other things being equal, a high-viscosity oil demands a coarser mesh than one of low viscosity. A screen made up of five wires to the inch proved most efficient with a moderately fine sand carrying oil of 14 to 15° gravity. The erroneous belief that the function of screen-casing is to prevent the entry of sand in oil-wells and thus to prevent pumping-troubles leads to the selection of too fine a mesh in many instances. The mesh had better be too coarse than too fine. Screen-pipe came into use and was devised in connection with water-wells and it was natural that the same rules were thought applicable when it was introduced in the oil-fields.

Pump Operation. A properly installed and operated plunger-pump will handle a surprising quantity of sand; in fact it may be said that it is capable of pumping sand containing oil rather than oil containing sand. It is not at all unusual for one of these pumps to handle a mixture containing 50% of sand by volume. A record should be kept of the performance of the pump on each well, depth at which it is pumping, date when new valve-seats or balls were substituted for the old, when the barrel was removed, and on what date the tubing was lowered. The lasting qualities of a pump are directly dependent upon the quantity of sand produced, and, as this varies with each well, the importance of keeping a record of pump performance is apparent. A barrel may require renewal every six weeks on one well, while on another it shows but slight wear after three months' use. The common practice of allowing a well to pump until the barrel becomes so worn that the production dwindles to a small stream or until some accident or breakage necessitates pulling, should be condemned. Each pumping-well should be studied and every effort made to maintain the production not only of oil but of sand.

The well should be tubed to such a depth that the maximum quantity of sand which the pump is capable of handling reaches the barrel at all times. This point can be determined only by experiment and gradual lowering of the tubing as sand production diminishes. Continued pumping of sand may save expense and labor of cleaning out 'dead' sand with cable-tools and bailers. In order to determine the exact condition of the barrel and plunger it is essential that both be removed from the well, washed with distillate, and then tested for fit and the absence of lateral play between the plunger and the barrel. The common practice of removing only the rods and plunger for examination is to be condemned. The pumping of sand is troublesome and means much work around the wells. For this reason there is a tendency to avoid it. A long stroke is advisable for pumping wells producing sand. The wrist-pin should be carried in the 'second hole.' If a valve becomes clogged with small gravel or sand it may often be freed by 'shaking up the well' by runing the pump at high speed for a few strokes. Twenty-five strokes to the minute is the usual pumping-rate when the rods drop freely, and this speed prevents the sand from settling.

Methods of Overcoming a Decline in Production. After a well has produced sand for a time varying from months to years it gradually diminishes in output even though the well is tubed to the bottom. In such cases methods are used to 'liven up' the well and increase production. Steam has been used in such wells and 'swabbing' is commonly practised, but the best method is probably the introduction of hot crude-oil. Where this method fails it is because of defective casing, either screen or perforated, or else the hot oil is improperly applied.

The best practice is to heat about 100 bbl. of crude-oil almost to the boiling-point and allow it to flow by gravity or else pump it down the well casing. It is usually treated in a nearby tank with steam-coils. Although some operators introduce it through the tubing, this practice has the disadvantage that the necessary stopping of the pump may cause it to 'sand up.' The effect of the hot oil is to wash the screen or perforations and to lower the viscosity of the underground supply, causing both the oil and sand to flow more readily toward the well.

The hot oil need not remain in the well for more than one-half to three-quarters of an hour, and it is then pumped out together with large quantities of sand and 'live' oil, oftentimes accompanied by considerable gas. It frequently happens that so much sand enters the well following this treatment that the pump is unable to handle it. In such a case two or three joints of tubing are removed, the barrel afterward being gradually lowered as the sand becomes exhausted. After a few weeks the pump again reaches bottom, when another 'hot oiling' is given.

There is no fixed rule as to the frequency of this treatment. This can be determined only by experiment and is dependent largely upon the age of the wells. In some cases it may be applied once a week with beneficial results, while in others once a month is sufficient.

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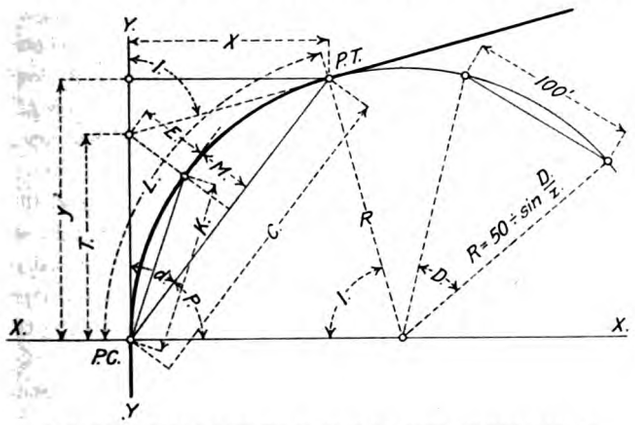
Equations for the Elements of the Circle

By J. A. KITTS*

The utility of purely mathematical graphs and equations and the advantages of a combination of polar and rectangular co-ordinates have not been generally recognized in the treatment of simple curve problems. The graphical representation of the elements of the circle, shown herewith, combines the two mathematical aspects, polar and rectangular co-ordinates. The relation of the arbitrary idea of 'degree of curve' to the purely mathematical equations is also indicated. The degree of curve D, as used in railroad practice, has been arbitrarily assumed as the central deflection-angle subtending a 100-ft. chord. D is equal to twice the angle whose sine is $\frac{50}{R}$; or chord $C = 100$ ft. $= 2R \sin \frac{1}{2}D$; and $R = \frac{50}{\sin \frac{1}{2}D}$. It is more practical to consider the elements of the circular curve as functions of the radius of curvature rather than as functions of the degree of curvature; however, the



GRAPHICAL REPRESENTATION OF ELEMENTS OF THE CIRCLE.

Equations for above:

Rectangular co-ordinates $y = \sqrt{2Rx - x^2}$.

Polar co-ordinates $C = 2R \cos P$.

two ideas may be combined and the advantages of both retained as indicated in the following equations.

Having given any two elements, the others may be found by the following equations:

x = ordinate = tangent offset $= \frac{C^2}{2R}$

$= R - \sqrt{(R+y)(R-y)} = 2R(\sin \frac{1}{2}I)^2 = 2R(\sin d)^2$

$= R$ vers $I = R$ vers $2d = R$ vers D, when C equals 100 ft.

$= R \sin I \tan \frac{1}{2}I = y \tan \frac{1}{2}I = y \tan d = T \sin I$

$= y \cot P = C \sin d = C \sin \frac{1}{2}I = 100 \sin \frac{1}{2}D$ when $C =$ 100 ft.

$= C \cos P = 4M$ (approximately).

y = abscissa $= \sqrt{x(2R-x)} = \sqrt{\left(C + \frac{C^2}{2R}\right)\left(C - \frac{C^2}{2R}\right)}$

$= R \sin I = R \sin D$, when $C = 100$ ft.

$= x \cot \frac{1}{2}I = x \cot d = C \cos d = x \tan P = C \sin P$.

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R = radius $= \frac{x^2+y^2}{2x} = \frac{C^2}{2x} = \frac{K^2}{2M} = \frac{C^2-4M^2}{8M} = \frac{M}{\text{vers } \frac{1}{2}I} = \frac{M}{1-\cos \frac{1}{2}I} = \frac{y}{\sin I} = y \csc I = T \cot \frac{1}{2}I = \frac{E}{\text{exsec } \frac{1}{2}I} = \frac{E}{\sec \frac{1}{2}I - 1} = \frac{57.29578L}{I} = \frac{x}{\text{vers } I} = \frac{x}{1-\cos I} = \frac{C}{2 \sin \frac{1}{2}I} = \frac{50}{\sin \frac{1}{2}D}$ etc., $= \frac{C}{2 \sin d} = \frac{C}{2 \cos P} = \frac{C \csc P}{2} = \frac{E}{\tan \frac{1}{4}I \tan \frac{1}{2}I} = \frac{M}{\sin \frac{1}{2}I \tan \frac{1}{4}I} = \frac{x}{\sin I \tan \frac{1}{2}I}$

C = chord = polar radius vector

$= \sqrt{2Rx} = \sqrt{2R[R - \sqrt{(R+y)(R-y)}]} = \sqrt{x^2+y^2}$

$= 2\sqrt{M(2R-M)}$

$= 2R \cos P = 2R \sin \frac{1}{2}I = 2T \cos \frac{1}{2}I = 2M \cot \frac{1}{4}I$

$= 2R \sin \frac{1}{2}D$, when $C = 100$ ft.

$= 2T \cos \frac{1}{2}D$, when $C = 100$ ft.

$= 2R \sin d = 2T \cos d = \frac{2E \sin \frac{1}{2}I}{\text{exsec } \frac{1}{2}I}$

$= 2T \sin P = \sqrt{2Ty} = \frac{2TM}{E} = \frac{2MR}{T}$

T = sub-tangent = tangent distance

$= R \tan \frac{1}{2}I = R \tan d = R \cot P$

$= E \cot \frac{1}{4}I = E \cot \frac{1}{2}d = E \tan P$

$= \frac{C}{2} \cos \frac{1}{2}I = \frac{C \sec \frac{1}{2}I}{2}$

$= \frac{x}{\sin I} = x \csc I = \frac{E+M}{\cos P} = (E+M) \sec P$

$= \sqrt{E(2R+E)} = \frac{CE}{2M} = \frac{Rx}{y} = \frac{2MR}{C} = \frac{C^2}{2y} = \frac{C(E+M)}{x}$

M = middle ordinate

$= R - \sqrt{\left(R + \frac{C}{2}\right)\left(R - \frac{C}{2}\right)} = R$ vers $\frac{1}{2}I = R$ vers d

$= R \sin \frac{1}{2}I \tan \frac{1}{4}I = \frac{C \tan \frac{1}{4}I}{2} = C \cot P$

$= E \cos \frac{1}{2}I = E \sin D = E \cos d = T \cot \frac{1}{2}I$ vers $\frac{1}{2}I$

$= \frac{Ey}{C} = \frac{EC}{2T} = \frac{C^2}{8R}$ (approximately) $= \frac{x}{4}$ (approximately)

E = external distance

$E = R$ exsec $\frac{1}{2}I = R$ exsec $d = R \tan \frac{1}{2}I \tan \frac{1}{4}I$

$= T \tan \frac{1}{4}I = T \cot P = T \tan d = \sqrt{T^2+R^2} - R$

$= M \sec \frac{1}{2}I = M \sec d = M \csc P = \frac{RM}{R-M}$

$= \frac{T^2}{R} = \frac{Tx}{y} = \frac{2MT}{C} = \frac{MC}{y}$

K = sub-chord

$= \sqrt{2RM} = \sqrt{R(2R - \sqrt{(2R+C)(2R-C)})} = 2R \sin \frac{1}{4}I$

$= 2R \cos \frac{1}{2}P$

L = length of arc

$= \frac{100I}{D}$ (railroad practice only)

$= 0.01745329\,IR = 8K - \frac{C}{3} = 0.0174\,R\,(180° - 2P)$

I = central deflection angle

$= 2d = 180° - 2P$

$\sin I = \frac{y}{R} = \frac{x}{T} = \cos 2P$

$\tan I = \frac{T}{y-T} = \frac{y}{R-x}$

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$$\csc I = \frac{R}{y} = \frac{T}{x}$$

$$\text{vers } I = \frac{x}{R}$$

$$\sin \tfrac{1}{2}I = \sin d = \frac{C}{2R} = \frac{E+M}{T} = \frac{x}{C} = \cos P$$

$$\cos \tfrac{1}{2}I = \cos d = \frac{C}{2T} = \frac{M}{E} = \frac{y}{C} = \sin P$$

$$\tan \tfrac{1}{2}I = \tan d = \frac{2M}{C} = \frac{E}{T} = \frac{T}{R} = \frac{x}{y} = \cot P$$

$$\cot \tfrac{1}{2}I = \cot d = \frac{y}{x} = \frac{R}{T} = \tan P$$

$$\text{vers } \tfrac{1}{2}I = \text{vers d} = \frac{M}{R}$$

$$\text{exsec } \tfrac{1}{2}I = \text{exsec } d = \frac{E}{R}$$

P = polar angle.

$= 90° - \frac{1}{2}I = 90° - d$

d = tangential deflection angle

$= \frac{1}{2}I = 90° - P$

EXAMPLE

Given $I = 23°$, R = 500 ft., it is desired to place points on the curve by tangential deflection angles, d_1, d_2, etc., of 1° and multiples; chord measurements to be made as vectors.

$T = R \times \tan \frac{1}{2}I = 500\ (0.20345) = 101.725$

$C = 2R \sin \frac{1}{2}I = 2R \sin d$

$L = 0.01745329\ IR$

d	sin d	C Ft.	L Ft.
1°	0.01745	17.45	17.45329
2°	0.03490	34.90	.....
3°	0.05234	52.34	.....
4°	0.06976	69.76	.....
5°	0.08715	87.15	.....
6°	0.10453	104.53	.....
7°	0.12187	121.87	.....
8°	0.13917	139.17	.....
9°	0.15643	156.43	.....
10°	0.17365	173.65	.....
11° 30′	0.19937	199.37	200.713

EXAMPLE

Given: logging chute, $I = 38°\ 22'$.

Required, curve of minimum radius to accommodate a 32-ft. log; points on curve to be placed by tangential deflection angles and successive 50-ft. chords.

Assuming that a 4-in. middle ordinate on a 32-ft. chord will give a satisfactory radius:

$$R = \frac{C^2 - 4M^2}{8M} = \frac{32^2 - 0.4444}{2.667} = 400 \text{ ft. approximately}$$

$T = 400 \tan \frac{1}{2}I = 400 \times 0.34791 = 139.164$ ft.

$$\sin d = \frac{C}{2R} = \frac{50}{800} = 0.0625;\ d = 3°\ 35'$$

$19°\ 11' - 17°\ 55' = 1°\ 16'$

Final chord $= 2R \sin 1°\ 16' = 0.02211 \times 800 = 17.688$

No.	d	C Ft.
1	3° 35′	50
2	7° 10′	50
3	10° 45′	50
4	14° 20′	50
5	17° 55′	50
6	19° 11′	17.69

Shipments of portland cement in the United States during 1916 were 94,500,000 barrels, or 7,500,000 barrels more than in 1915. The production was 91,200,000 barrels, or 5,000,000 barrels more than in 1915.

CONNECTING ELECTRICAL CIRCUITS TO WATER-PIPES

The accepted theories regarding the necessity of preventing the collection of electric currents by water-pipes as well as the danger of electrolysis where the currents leave the pipes, were opposed by Burton McCullom and O. S. Peters in a paper presented before the Central States Water Works Association.

The paper gives the data and the theory upon which the conclusions are based, the latter being as follows:

1. Many of the dangers which arise from electrical circuits may be eliminated by grounding these circuits.

2. Of the means of grounding electrical circuits, water-pipes are by far the most desirable.

3. There is no danger of electrolysis by such stray alternating currents as may result from grounding low-voltage alternating-current circuits.

4. Direct-current circuits should be grounded at but one point, preferably at the station.

5. Where conditions permit, two or more ground connections should be made on each secondary system.

6. In case of any individual low-voltage circuit in which a number of ground connections to pipes are made, the grounding should be confined to one pipe-system. Measurements of the resistance of the pipe-line between the farthest removed points of connection should be made to make certain there are no insulating joints in the part of the pipe-line which may cause the electric circuit to carry heavy stray currents from railways.

7. In making either single or multiple ground-connections to water-systems, unless it is positively known that there are no insulating joints nearby, the adequacy of the ground connection should be determined by measurement of its resistance. Ground connections should not be made to cement-joint lines, or to other lines in which there are many joints of high resistance.

8. Connections to pipe-lines may be made by screwing a brass plug into the bell in the case of cast-iron pipes or by clamps or soldering to service pipes. Soldering is preferable to clamps where it is feasible.

9. Connections to service pipes should be made at the point where there is the least likelihood of the pipe being disconnected between the connection and the main. If the water-meter comes between the connection and the main, a 'jumper' of the same size as the ground wire should be put around it.

10. Connections to gas-pipes should be prohibited chiefly on account of the chance of explosions or fires.

The strength of cast-iron is increased by the addition of wrought-iron scrap added during the melting process, the increase being approximately as follows: With 100 parts of cast iron, 10 parts of wrought iron increases the strength 2%; 20 parts of wrought iron increases the strength 32%; 30 parts of wrought iron increases the strength 60%; and 40 parts of wrought iron increases the strength but 33%. The best result is therefore produced with 30% wrought iron.

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The Hydraulic Air-Compressor

By A. E. CHODZKO

It is a noteworthy fact that the Pacific coast of the United States, so liberally supplied with natural sources of water-power, already utilized in a number of important hydro-electric installations, should not present a single case of application of a process that has been turned to good advantage by our Canadian neighbors, as also in a few localities in this country and in Europe, namely, the hydraulic compression of air.

The increase of activity in the mining industry, caused by the present upheaval and by the fact that new metallic substances have recently been enhancing the general demand for further development in the opening of mineral deposits, may lend interest to a brief description of a device that some eminent technical writers have been satisfied to pass with the cursory remark that it is "the reverse of the air-lift." Here not improbably lies one reason for the indifference manifested toward hydraulic compression: a common notion exists that the air-lift, while a convenient and widely used contrivance for well-pumping, is unfit for mining practice, and the above opinion, expressed by accepted professional authorities, contributes to relegate in the make-shift class a system that, when rationally used, surpasses in efficiency the most advanced types of mechanical pumping-plants.

Another cause of reticence on the subject may be found in the fact that so far, its successful applications have been made on a large scale, so that the superintendent of a mine of moderate size, and disposing of a limited amount of water, naturally enough deems it useless to look into its possible use for his own requirements. Finally, it is safe to say that while the process itself is by no means novel, little is generally known about its practical use; as in other questions of commercial popularity, both truth and error can be found in these arguments. They are well worth a few moments of attention because not uncommonly have valuable processes or articles been condemned simply because they were applied out of season and under faulty conditions.

In the first place, and without dealing with the air-lift beyond the statement that under ordinary and practicable circumstances it is eminently adapted to mining work, nor is it true that the principle of operation is reversed in hydraulic compression.

True it is that they present some traits of similarity; in both of them, air and water are circulated side by side in immediate contact, and a satisfactory degree of efficiency requires a proper volumetric proportion between the two fluids; in both, also, the principle of operation lies in the difference of weights between two liquid columns in communication. The modes of action of the two machines are, nevertheless, widely different, as also are the determinations of their elements.

J. P. Frizell, who originated that system in 1878, contends that the volume of air drawn by the water into the induction-pipe (Fig. 1) automatically adjusts itself to balancing its contents and those of the return-column. That statement is too vague to satisfy a man who, having at his disposal a given amount of water, wants to know how much air he can raise with it to a given pressure. C. H. Taylor, of Montreal, attempted to answer that question by constructing in 1896 at the Magog mills, Quebec, a hydraulic plant that successfully supplied power to a number of compressed-air motors. In that installation, a volume of free air from 1377 to 1616 cu. ft. per minute was compressed to 52 lb. effective per square inch by a volume of water from 6122 to 7162 cu. ft. per minute respectively, with a fall of from 21.2 to 22.3 feet.

Prof. C. H. McLeod, of McGill University, performed in August 1896 on the Magog plant some tests that showed an efficiency ranging from 53.5 to 62.4%. Encouraging as were these results, they could not outshine customary makes of air-compressors in the competitive field; the tests suggested a better proportion between the main parts of the machine, and further attempts justified that prevision.

The efforts of the promoters of the system were rewarded by such marked progress that a hydraulic compressor nowadays can be established under guarantee of showing a higher total efficiency than a reciprocating or centrifugal machine for the same capacity and air-pressure. That efficiency is permanent, because deterioration is practically absent, and no apparent reason exists, barring accident, why a well constructed hydraulic compressor should not be in as good condition after years of continous use as on the day when water was first turned on. Nor does its relative superiority stop here; while, like any power-plant whatever, the hydraulic compressor demands some attendance, this does not compare with that required by a mechanical plant of like capacity.

This, indeed, does not imply an unrestricted commendation of that type of compressor; its success is primarily subservient to natural conditions that do not exist everywhere, even in regions where it would seem to warrant consideration. But when these requisites are fulfilled, the manager in need of compressed air should be enabled to figure out, at least approximately, as he would for steam, electric, or water power, the nature and the cost of the work involved in the prospective equipment.

Many will hesitate to apply for advice to exclusive firms, who not uncommonly seem to treat a mere request for information as the forerunner of an immediate order,

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and they naturally prefer to work the matter out by themselves. Professional inquiries received from mining men satisfied me that the elements of such estimates are lacking, and they have prompted me to present a few pointers that may prove useful. Such suggestions are the outcome of a solution of the problem of hydraulic compression prepared for my personal use, in an effort to co-ordinate the various requirements and physical features of the case. Similar, or perhaps identical, formulæ may have been propounded elsewhere; they have not come under my observation.

A strictly analytical treatment of the subject would prove both a useless and a hopeless task: useless because to the man of action, for whom these notes are intended, the sight of a forbidding array of differential equations is a sure incentive to closing the book and dismissing a question presented in that shape; hopeless, because problems of that nature unavoidably involve some purely practical factors, our correct knowledge of which is at best very restricted. If they follow definite laws, these are still, to a large extent, enshrouded with uncertainty, and so long as the requirements do not trespass the limits of present practice, one must rest content for the time being with records of experiment and actual performance as a corrective to the common tendency to generalize unduly the results of limited observations. Such records are unfortunately scarce; too often inquiries of that nature are checked by commercial reticence.

The proposed line of computation assumes only an elementary familiarity with mathematics and physical mechanics; first using it as a checking process, it will be applied to the published results of elaborate tests conducted on a large and successful installation of hydraulic compressors; it next will be used for treating a special case in actual mining practice, the object being to impart an idea of the conditions under which a hydraulic plant deserves competitive comparison with the usual makes of air-compressor.

Again referring to Fig. 1, which indicates the general outline of a hydraulic compressor, air and water will be traced step by step during their passage through the machine, the following notations being used:

p_0 = atmospheric pressure in pounds per square inch.
p_1 = absolute highest air-pressure in pounds per square inch.
Q = volume in cubic feet of free air available for useful purposes.
c = volume in cubic feet of free air available for effecting compression.
R = volumetric ratio of the total amount of entrained air to the volume of water.
S = weight in pounds of one cubic foot of free air at pressure p_0.
V_1 = mean velocity in feet per second along induction pipe.

Induction Column. Water from the fore-bay enters the induction-pipe at its top, together with a certain volume of entrained free air, depending upon the velocity of the water. Various devices, which need not be examined at this time, have been proposed for improving the entraining action of water on the air; it would appear that their main advantage consists in dividing that air into small bubbles, and thus facilitating cooling during compression, but the amount of entrained air is practically the same with or without these devices.

That fact was emphatically asserted by Frizell, and it is confirmed by more recent observation (Peele, 'Compressed Air Plant,' p. 245). At any rate, a mixture of water and of air bubbles is falling along the induction-pipe, the air being gradually compressed as the hydrostatic head increases with the distance below the level of water in the fore-bay. The entire amount of that air, however, is not available for useful purposes, because part of it becomes dissolved in the water.

The latter at saturation contains air to one-twentieth of its volume, irrespective of pressure. The result is that one cubic foot of water entering the induction-pipe contains in dissolution, and with no increase of volume $\frac{1}{20}$ cu. ft. of free air; but as the fall proceeds and that air becomes compressed, its volume diminishes, so that, in order to keep up saturation, the difference between $\frac{1}{20}$ cu. ft. and the actual volume occupied by the partly compressed air must be made up at the expense of the non-dissolved entrained air.

A steady and increasing drain therefore takes place on the initial volume of air, along the induction pipe, until the air and water mixture reaches the lower end of that pipe.

The 0.05 cu. ft. of free air held in dissolution at entrance has now become $0.05\ \frac{p_0}{p_1}$ cu. ft. of compressed air at pressure p_1 and the drain on the entrained air, also measured in compressed state, is $0.05\ \left[1-\frac{p_0}{p_1}\right]$ cu. ft., corresponding to $0.05\ \frac{p_1}{p_0}\left[1-\frac{p_0}{p_1}\right]=0.05\left[\frac{p_1}{p_0}-1\right]$ cu. ft. free air.

In other words, if c cubic feet of water enter the induction-pipe in one second, the total volume of free air moving with it is Rc cu. ft., out of which the water holds in saturation $0.05\ c$, making the volume of entrained free air at entrance to induction.

$$Rc-0.05\ c=c(R-0.05)\ \text{cu. ft. per second.}$$

When the mixture reaches the bottom of the induction-pipe, the drain on the entrained air to maintain saturation is, as above stated, $0.05\ c\ \left[\frac{p_1}{p_0}-1\right]$ measured in free air, leaving for useful purposes

$$c(R-0.05)-0.05\ c\left[\frac{p_1}{p_0}-1\right]$$
$$=c\left[R-0.05\frac{p_1}{p_0}\right]=Q$$

cubic feet of free air per second available for use, and therefore

$$R=\frac{Q}{c}+0.05\ \frac{p_1}{p_0}$$

The limits of available space and of the reader's forbearance would be exceeded by the tedious unfolding of simple calculations that leads to the following results:

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Mean weight per cubic foot of mixture of air and water along the induction-pipe:

$$m = \frac{62.4 + S\,(R - 0.05)}{2}\left[\frac{1}{1+R} + \frac{1}{1+R\,\frac{p_o}{p_1}}\right] \text{lb.}$$

Mean volume of mixture passing per second through induction-pipe:

$$c_1 = \frac{c}{2}\left[1.9 + R\left(1 + \frac{p_0}{p_1}\right)\right] \text{ cubic feet.}$$

V_1 is, in feet per second, the mean net velocity of fall of that mixture, supposed to be constant along the induction pipe.

The corresponding diameter d_1 in feet is given by the relation

$$0.7854\ d_1^2\ V_1 = c_1 \text{ or } d_1 = 1.128\sqrt{\frac{c_1}{V_1}}$$

Frizell states that small air-bubbles, say $\frac{1}{4}$-inch diam., in suspension in still water, have a natural tendency to rise with a velocity of 0.8 ft. per second, varying as the square root of the bubble's diameter. And, therefore, if we assume that the compressed air at the foot of the induction-pipe is in the shape of small bubbles of that size, it will easily be found that the rising velocity at the surface would be $W_o = 0.8\left(\frac{p_1}{p_o}\right)^{1/6}$ feet per second, so that, while the net average velocity is V_1 its actual value at the top of the induction must be $(V_1 + W_o) = V'_1$, and as the velocity is supposed constant, this value must prevail along the induction.

The following portions of the total head are lost during the fall: Frizell estimates the necessary head to induce air by entrainment at the top of the induction-pipe to be 1 foot $= h_1$.

The entrance head, covering contraction is generally reckoned as one-half the velocity-head, or $0.0078(V'_1)^2 = h_2$.

The velocity-head $0.0155\ (V'_1)^2 = h_3$.

The friction-head on the length H of the induction is $\frac{H}{d_1}\left(\frac{4\,V_1^2 + 5\,V_1 - 2}{14400}\right) = h_4$.

There is, besides, a loss due to the disruption, in the separation-chamber, of the induction-column moving at the assumed velocity (V'_1). The corresponding head is $\frac{m\,c_1}{2\,g}\,(V'_1)^2$.

The net work done by the falling water is therefore

$$mc_1\left[H - (h_1 + h_2 + h_3 + h_4) - \frac{(V'_1)^2}{2\,g}\right] \text{ ft. lb.}$$

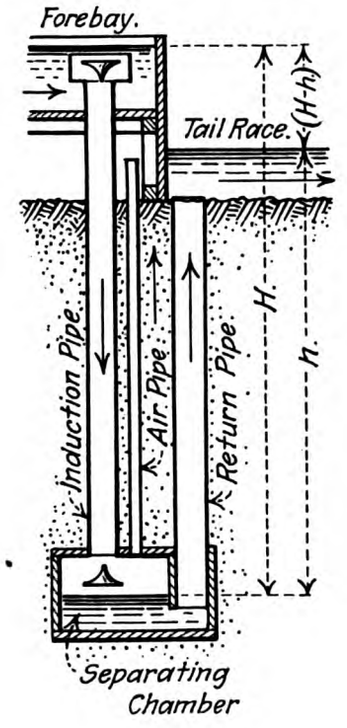

Fig 1

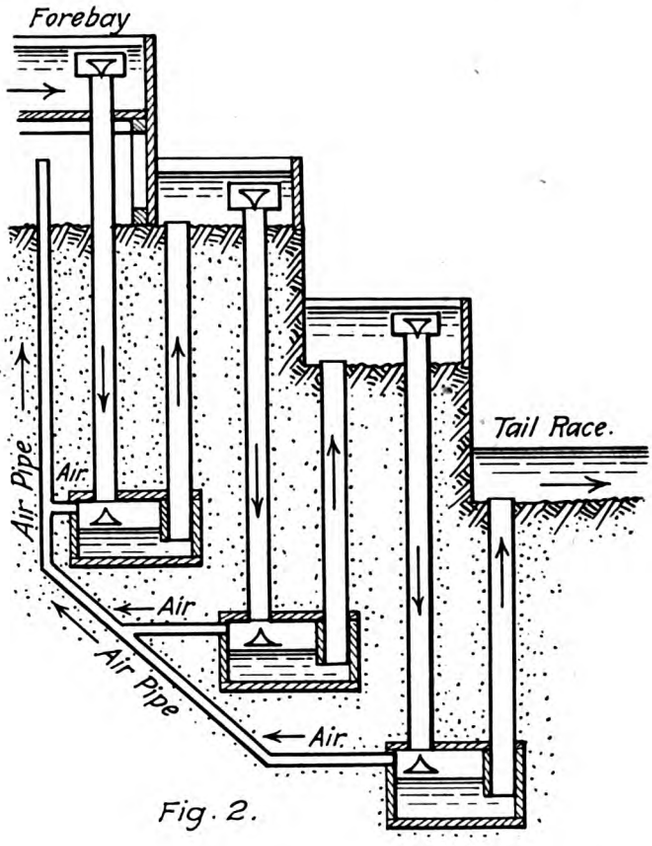

Fig. 2.

Return Column. When the mixture issues from the induction-pipe into the separating-chamber, the compression of the entrained air has been completed; the descending column meets a stationary shield that spreads it radially, at right angles with its former direction, and facilitates the separation of the air from the water. The former naturally seeks the upper part of the separating-room, where it enters the air-main. It is obvious that the larger this room is horizontally, the more complete will that segregation be, because the sudden increase of area brings the water to a comparative rest, and it abandons the entrained air-bubbles. The water remains saturated with air, and fills the lower portion of the room, where the submerged entrance to

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the return-shaft is placed. The top of it opens in the tail-race, and its vertical depth determines the effective air-pressure.

The size of that ascending passage varies in the few existing installations of that type: it generally is a shaft, vertical or inclined, either enclosing the induction-pipe, or independent of it, but as a rule, of a materially larger cross-section. This, however, is not without exception: Kent (page 623) mentions an installation with a 3-ft. induction and a 4 ft. 9 in. return-pipe, and circumstances are readily conceivable where both may be laid on the inclined surface of the ground. If a is the uniform area of the return-passage in square feet, the mean velocity is $V_2 = \frac{c_2}{a}$ when c_2 is the mean volume in cubic feet per second of the ascending column of air and water.

If the return-passage is a circular pipe of diameter d_2 feet, then

$$V_2 = 1.273\left(\frac{c_2}{d_2^2}\right)$$

Whatever be the sectional shape of the return-passage, d_2 may be taken as the diameter of an equivalent circular section.

The mean volume c_2 passing per second is

$$C_2 = c\left[1 + 0.025\left(\frac{p_1}{p_0} - 1\right)\right] \text{ cu. ft.}$$

The mean weight per cubic foot is

$$m_1 = \frac{62.4 + 0.05\left(\frac{p_1}{p_0} - 1\right)}{2}\left[1 + \frac{1}{1 + 0.05\left(\frac{p_1}{p_0} - 1\right)}\right] \text{ lb.}$$

The losses occurring during the return flow are represented by

$$\text{a velocity-head } 0.0155\ (V_2 - 0.8)^2 = h_5,$$

$$\text{a friction-head } \frac{l}{d_2}\left(\frac{4V_2^2 + 5V_2 - 2}{7200}\right) = h_6,$$

when l is the actual length of the return-shaft in feet. The divisor 7200 applies to a rough shaft blasted out of the rock; with a smooth passage, that divisor should be 14,400.

A pressure-head $2.31\ (p_1 - p_0) = h$.

And finally, the work of isothermal compression of Q cu. ft. of free air from p_0 to p_1 is $144\ p_0\ Q$ hyp. log. $\frac{p_1}{p_0} = W$.

The total resisting work is therefore $[m_1\ c_2\ (h + h_5 + h_6) + W]$ ft. lb. and equating it to the net work done by the water:

$$m\ c_1\left[H - (h_1 + h_2 + h_3 + h_4) - \frac{V_1'^2}{2g}\right] = m_1\ c_2\ (h + h_5 + h_6) + W. \quad (1)$$

The efficiency of the process is the ratio of the useful work to the work of falling water, or

$$E = \frac{W}{62.4\ c(H - h)} \quad (2)$$

These two expressions furnish all the fundamental data necessary for an installation of hydraulic compression to meet given conditions. The manner of using them will now be exemplified on an existing plant erected in 1906 at the Victoria copper mine, near Rockland, in Ontonagon county, Michigan, the description of which can be found in Peele ('Compressed Air Plant,' pp. 242, *et seq.*) and in an article by C. H. Taylor in the *Mining and Scientific Press* of August 18, 1906.

The plan will ultimately comprise three identical units, one of which was in operation when tests were conducted by Prof. F. W. Sperr in May 1906.

Their results, published in the above papers, present slight discrepancies of pressure in connection with the dimensions given in the two descriptions, but that does not affect the result in view, namely, the concordance of the actual data with the above formulæ.

The results of the tests are as follows, in one of three cases:

Atmospheric $p_0 = 14$.
Absolute air-pressure $p_1 = 128$.
Cubic feet free air per second $Q = 198.83$.
Cubic feet water per second $c = 247$.
Diameter of induction $d_1 = 5$ ft.
Working-head $H\text{-}h = 70$ ft.
Return-shaft 540 ft. long $= l$, 10 by 10 ft. (?) with a 2-ft. air-main concreted.
Efficiency $E = 0.8227$.
Assumed temperature 60° F. $S = 0.0726$.
Applying the previous formulæ, the results are
$R = 1.262$.
$m = 41.273$.
$c_1 = 407.55$ cu. ft.
$m_1 = 53.396$ lb.
$C_2 = 297.28$ cu. ft.
$W = 887{,}061.75$ ft. lb.

The value of the main velocity V_1 is arbitrary, and lacking a definite law of correlation between that element of the question and the volume of entrained air, one may safely assume that they vary in the same direction, as also do the inertial and frictional resistance, while the size and the cost of the induction-pipe becomes less.

Ivens ('Pumping by Compressed Air,' p. 124) mentions a lift of 840 ft. with a maximum velocity of 22 ft. per second in the eduction-pipe. This has reached 25 ft. in other cases.

In the present instance, a 5-ft. induction-diameter gives

$$V = \frac{c_1}{19.635} = 20.756 \text{ ft.}$$

and assuming the same value, for the sake of comparison, with

$$W_0 = 0.8\left(\frac{p_1}{p_0}\right)^{1/6} = 1.157 \text{ ft. sec.}$$

as the rising velocity at surface, $V'_1 = 21.913$ ft., and therefore $h_1 = 1$; $h_2 = 7.443$; $h_3 = 3.721$; $h_4 = 0.025\ H$; and $\frac{(V'_1)^2}{2g} = 7.443$, making the net work of water $16{,}820.81\ [0.975\ H - 19.607]$ ft. lb.

The width of the return-shaft, not given, is assumed equal to its height, namely, 10 ft. Concreting of the 2-ft. air-main occupies 3 by 3 ft. = 9 sq. ft., leaving a net area of 91 sq. ft. with an equivalent diameter of 9.52 feet.

The mean velocity in the return-shaft is

$$V_2 = \frac{c_2}{91} = 3.267 \text{ ft.}$$

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and therefore $h_5 = 0.0155\ (3.267 - 0.8)^2 = 0.092$ ft.

$h_6 = \frac{540}{9.52} \times \frac{57.027}{7200} = 0.449$ ft.

h = as per descriptions $= 272.000$ ft.

$h + h_5 + h_6 = 272.541$ ft.

Equation (1) becomes

$$16820.81\ [0.975\ H - 19.607] = 15873.56 \times 272.541 + 887061.75.$$

$H = 337.99$, say, 338 ft.

and subtracting working-head 70 ft.

the pressure-head is 268 ft.

The efficiency is 0.823.

As a matter of fact, the value of H in the Victoria plant is 342 ft., with a pressure-head of 270 ft., a working-head of 72 ft., and an air-pressure of 117 lb., instead of 114 lb. given in the test's records. A shorter length of the total head H was therefore to be expected with the present data, and the above results established the practical conformity of the proposed solution with actual facts.

Another application will now be considered to the case of a mine where the available supply of water is scant, compared with the required amount of air.

The data furnished by the inquirers are

Altitude = 10,000 ft.

Temperature from + 90° to − 25° F.

Minimum flow of water = 500 m.i.

Volume of free air required for use = 2000 cu. ft. min.

Effective air-pressure per square inch = 100 lb.

The site makes it desirable to avoid, if possible, the use of heavy machinery and the necessity of important repairs.

An assumed repartition of temperature throughout the year places its mean value, between the mine and sea-level, at 48° F. and this gives

$p_o = 10.156$; $p_1 = 110.156$; $Q = 33.33$; $S = 0.054$; $c = 12.5$; $\frac{Q}{c} = 2.6664$; $R = 3.209$.

A series of calculations entirely similar to those used in the previous example give the following results:

Diameter of induction-pipe, 20 in.

Mean velocity in induction-pipe, 15.47 ft. sec.

Diameter of return-pipe, 28 in.

Mean velocity in return-pipe, 3.64 ft. sec.

Total height, $H = 310.86$ ft.

Working head, $H - h = 79.86$ ft.

Efficiency of the process, $E = 1.863$.

This means an impossibility.

Now, an ordinary air-compressor, operated by a water-wheel, would meet the present requirements, at a total efficiency of 55%, with a working-head of 271 ft. In a general way, it is true to say that theoretically any definite amount of water will perform any definite amount of work under a sufficient head. Nor does the rule suffer exception in the case of hydraulic compression; the recorded impossibility is chargeable, not to the system itself, but to the imposed combination of volume and pressure of the air.

The following results would be found, for the same volume of air and water as assumed in the last example:

Effective air-pressure (lb. per sq. in.)	50	25	8
Total head, H ft	216.7	148.99	82.38
Working head, $H - h$ ft	101.2	91.24	63.9
Efficiency	1.098	0.854	0.567

It appears therefore that under given volumetric conditions of air and water, there is a certain pressure corresponding to the maximum efficiency, the upper limit of which is necessarily below unity, on account of the loss incurred from the compression of the saturating air.

In mining, pressures of 100 lb. or thereabouts are generally desired for operating machine-drills. Lower pressures may, however, be useful, for instance, as sometimes suggested, to furnish the first stage of compression for a compound-piston machine; this would permit an ordinary one-stage compressor to perform the finishing stage to 100 lb., a result that could not economically be obtained in a single cylinder.

Another valuable use of low pressures is the operation of serial air-lifts, which only can be mentioned at this place. If, however, an effective pressure of 100 lb. is considered imperative, a hydraulic installation becomes possible by fractioning the plant into several consecutive units acting in parallel so far as air is concerned, and in series for the use of water; in other words, the same water is used several times in succession to produce a cumulative amount of air, the scope of the combination being only limited by the total available fall, controlled, of course, by considerations of economy.

Here are some results of such an arrangement. (Fig. 2.)

Effective air-pressure per sq. in.	100	100	100
Cubic feet of water per minute.	750	750	750
Cubic feet of free air per minute at each stage	1000	800	666.67
Number of serial stages	2	2.5	3
Total height, H ft	315.45	304.47	297.25
Working head, $H - h$ ft	84.45	73.48	66.25
Efficiency	0.881	0.811	0.749

It appears, therefore, that the hydraulic system of compression is adaptable to a variety of forms, under a high efficiency; it is, however, safe to say that its best field of application is characterized by large volumes of air and of water, and that, when their ratio, in the order here named, materially exceeds the unit, a mechanical installation seems, at first glance, more satisfactory.

The problem involves, however, too many conflicting factors to warrant rigid rules of limitation. One unique feature of this type of compressor is that it can be established in a case of emergency when more elaborate machinery would be altogether out of question; and in a remote locality, it may, on that account, prove extremely valuable.

Damascus steel, famous throughout the world, owes its peculiarly valuable qualities to the fact that it contains tungsten, according to Duc de Luynes, who published something on the subject in 1844.

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Elastic-Weight Theory Graphically Applied to Continuous Beams

By CYRIL PROVO HUBERT*

This method is based on the theory of elasticity, the law of flexure in solid bodies. While no authorities are quoted in support of the method, the practical utility of the theory cannot fail to commend itself. It is possible to study continuous beams, entirely independent of assumptions as to loading. This is a radical departure from the method outlined in the August 1916 issue

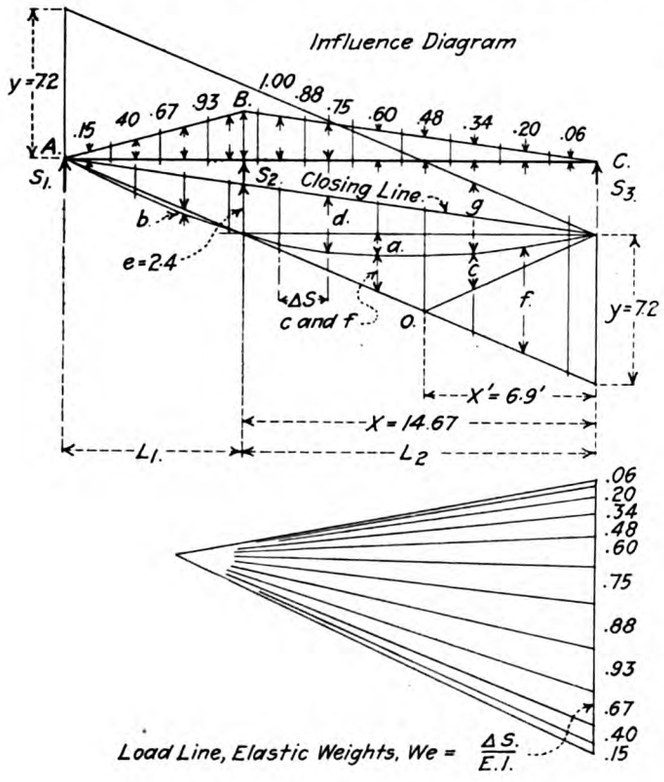

FIG. 1. DIAGRAM FOR DESIGN OF CONTINUOUS BEAMS.

of WESTERN ENGINEERING, yet both systems are in accord with the laws governing structural design.

The first illustrative example is an actual problem from my own experience. The structure was a mill building requiring the design of a series of continuous beams, all having the same span-lengths, but a different uniform loading in each case. The influence diagram, however, remained the same, it being necessary merely to allow for changed loading. The diagram was constructed as follows: The span-lengths were laid off to a convenient scale. Over the middle support a vertical line was erected of unit-length. The triangle ABC was then formed, representing the total elastic-weight area. The over-all length $L_1 + L_2$ was divided into eleven equal parts, though any other number would serve the purpose.

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It should be noted in this connection that in so doing the middle support was disregarded entirely. Next, each of these spaces was divided into half and the lengths of the lines within the elastic-weight area were scaled, the resulting figures representing the elastic weights for the chosen increment ΔS. The elastic weights, beginning with the first one on the right were laid off along the load-line of the polar diagram from the top downward. After establishing the pole, which may be at any point, the rays were drawn, completing the load-polygon from which the influence-diagram was constructed in much the same manner as an equilibrium polygon, by commencing from the left end-reaction and drawing each ray in its consecutive order, completing the diagram by means of the closing line shown. The relationship of the spans to the influence-curve was then obtained by producing a straight line from the left-hand supporting point to the line of right-hand support, being governed in direction by the intersection of the influence-curve and line of middle support.

It is then a simple matter to derive the bending moments and reactions from the influence values.

L_1 = Short span = 7.33 ft.

L_2 = Long span = 14.67 ft.

ΔS = Increment = 2 ft.

Moment at middle support =

$$-(\Sigma b + \Sigma a)\frac{x'}{y}.w\Delta s =$$
$$-(0.57-4.45)\frac{14.67}{7.2}.w.2' = -20.3w.$$

Since there are always crucial points determining the maximum moments, point O will serve to show how these points may be investigated.

Moment at point O =

$$(\Sigma c - \Sigma b)\frac{x'}{y}.w\Delta s =$$
$$(9.15-0.57)\frac{6.9}{7.2}.w.2' = +17.15w.$$

Middle support reaction =

$$\frac{\Sigma d.w.\Delta s.}{e} = \frac{18.12.w.2'}{2.4} = 15.1w.$$

Right end reaction =

$$\left(\frac{\Sigma f - \Sigma b}{y}\right).w\Delta s = \frac{21.98-0.57}{7.2}.w.2' = 5.95w.$$

To illustrate further the general application of this theory, Fig. 2 and 3 have been shown. In Fig. 2, the reaction at

$$S_2 = \frac{Py_2}{y_1} \quad \text{and} \quad w = \frac{y\Delta s}{I}$$

where S_1 = reaction at centre support, W = elastic weight for a section whose length equals ΔS, and I = the moment of inertia (constant or variable) of the beam.

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Fig. 3 shows a simple beam supported at one end and fixed at the other end. Here the moment at the fixed end

$$= \frac{L}{y} Pm$$

The computations for the continuous beam shown in Fig. 4 will be discussed to show how the elastic-weight theory, in connection with the established inflection-points, is applied to a continuous beam of three or more spans, either equal or unequal.

The inflection-points b are determined as described in the previous article. Having determined these points, proceed to draw the elastic-weight diagram c for the support under consideration. As a matter of convenience and greater clearness, the diagrams for supports S_2 and S_3 have been re-drawn (see d and f). It is evident that the treatment of the elastic weights in Fig. 1 cannot be applied directly to these two diagrams, for instead of establishing a unit-length over the support considered, there is a variation because of the span lengths becoming influencing factors. This will be discussed in connection with the elastic system for the support S_2.

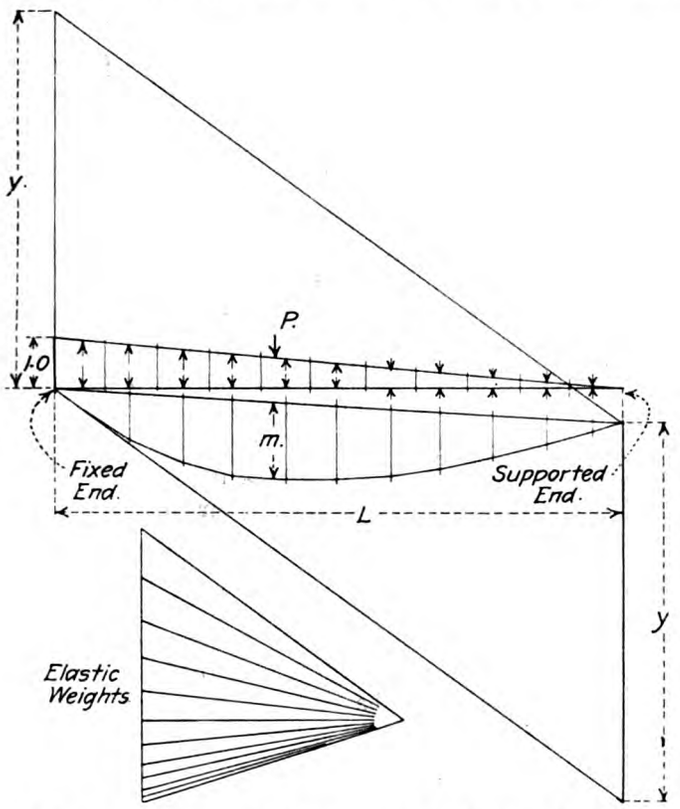

FIG. 3. DIAGRAM FOR BEAM SUPPORTED AT ONE END AND FIXED AT THE OTHER.

Lay off along the supporting line S_2, a distance equal to the span-length L_3, determining point O, from which point draw two straight lines, one passing through the left-hand inflection-point and the other through the right-hand inflection-point of the span, intersecting the next support. The distance y is then scaled off on the line of support and is the factor sought. When the span-length is large, it will be found necessary to introduce a constant to avoid having the lines run off the paper. In this particular case the constant $\frac{L_3}{n}$ was substituted.

The weight diagram can now be constructed. The total over-all distance $L_1 + L_2 + L_3 + L_4$ is divided into any number of equal parts and the elastic weights scaled,

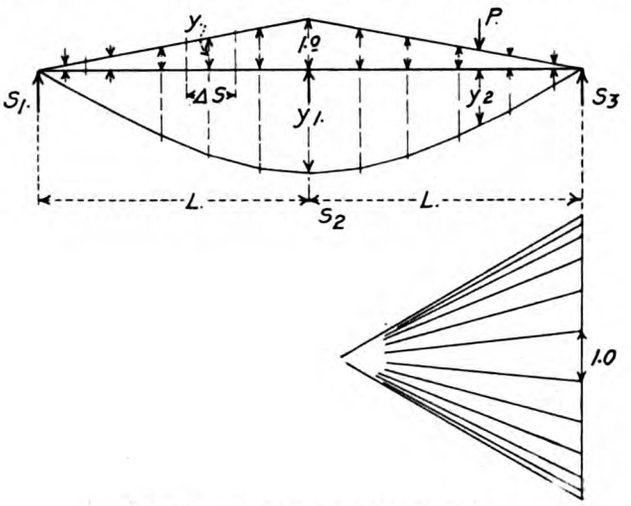

FIG. 2. DIAGRAM FOR SINGLE SPAN.

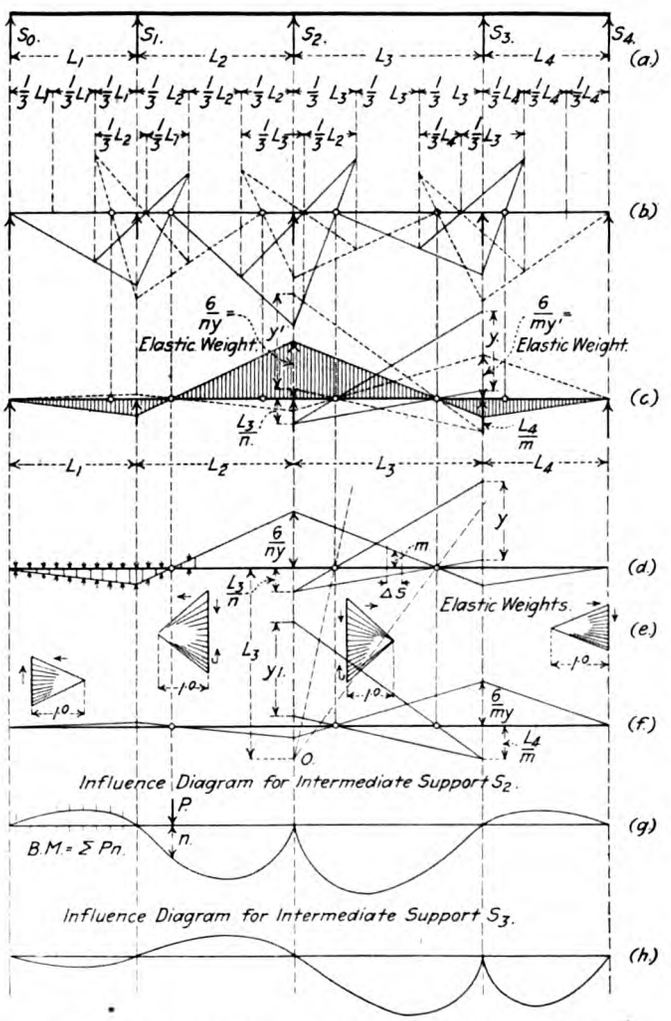

FIG. 4. COMPLETE DIAGRAM FOR CONTINUOUS BEAM.

not forgetting the constant. On an arbitrary vertical line lay off these weights making allowance for the negative and positive signs. With a pole distance equal to

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unity draw the polygon and the influence line for the intermediate support S_2. The bending moment $= \Sigma Pn$. This gives the bending moment for the support for which the elastic-weight diagram was drawn, where

$P =$ load

$n =$ influence-ordinate

For the computations the influence-diagram is composed of broken straight lines, while in reality, these are curves enveloping the intersections of these straight lines, but the difference is negligible. One advantage of this method is that it is unnecessary to re-compute the quantities as is the case with 'cut-and-try' methods.

USING A FUMAROLE TO GET STEAM

An ingenious Italian civil engineer has been successful in employing the heat of a fumarole near Volterra, in Tuscany, to develop 15,000 horse-power. In that district are numerous fissures in the ground from which a large and constant volume of steam escapes violently into the air. The steam contains several minerals in solution, of which boric acid is the most valuable, and this is saved and utilized in the manufacture of borax. The heat of these steam-vents has long been used in warming the dwellings near-by, but until recently only a small part of the steam available has been utilized. In 1903 the first attempt was made to employ the heat of the steam-vents as a source of power. A strong jet of the escaping steam was applied to a small rotary-motor, and this experiment resulting in some success, the steam was conducted to a small reciprocating-engine that was used to run a dynamo, generating enough electricity to light a part of the borax works. These applications proving satisfactory, an effort was made to make available a larger volume of steam by boring holes in the ground. These bore-holes were driven to a depth of from 300 to 500 ft. and were lined with iron pipe. The holes are from 12 to 20 in. diam. The steam issues under a pressure varying from 30 to 150 lb. per square inch, and the temperature is said to range from 300° to 375°F. For years the steam-jets have not diminished their activity, nor is there any decrease in the volume of steam or the pressure when additional holes are bored so long as they are not less than 50 ft. apart. It has been demonstrated that each hole will supply steam at a temperature of 300°F. with the equivalent of 1000 to 2000 theoretical horse-power per hour. The result of the early experiments has been followed up, and in 1906 the steam was applied to a 40-hp. engine with satisfactory results, as far as the generation of power was concerned, but the minerals in solution and the sulphuric acid in the steam had such a corrosive effect on the cylinder of the engine that frequent repairs were necessary. The introduction of the steam directly to the engine was discontinued and it was transferred to the boiler, using the heat of the steam, instead of fuel in the usual way, to raise the temperature of the water in the boiler, and producing a pressure in the boiler of about 30 lb. per sq. in. This boiler-steam was then passed through a super-heater and used to drive a 300-hp. condensing steam-turbine direct-connected to a three-phase generator, which supplied power and light to the works, and to the neighboring villages. This installation was so satisfactory that when coal became scarce and very expensive soon after the beginning of the War, the possibility of employing the steam-vents on a still larger scale was considered seriously. Three sets of condensing turbo-alternators were put in place, each of 3000 kw., operated with super-heated steam at 22½ lb. pressure that was generated in specially constructed tubular boilers of the marine type, and provided with aluminum tubes to resist the corrosive action of the acid. The steam used in driving the turbines is generated from water fed into the boilers, heat being supplied by steam from the vents. The boiler-steam is passed through aluminum pipes arranged between the boilers and the turbines. On its way the temperature is raised to about 300°F. by super-heated steam from the vents. The condensed steam from the turbines is returned to the boilers, and no natural steam comes in contact with the engines, thus obviating the corrosion of metal that had been the principal difficulty to overcome.

The success of this novel utilization of a natural source of heat and power suggests the possibility of its application in other regions where similar conditions exist. In California, near Mount Lassen, are numerous fumaroles and steam-vents, particularly in Hot Spring valley, and some application of the energy going to waste there possibly might be made in a manner similar to that adopted in Italy. On the Darragh ranch in Big Smoky valley, Nye county, Nevada, there is a large boiling spring, the temperature of which is stated to be 242°F., or 30° hotter than boiling water. Obviously, it is a possible source of power, but the water is utilized only by directing the stream into a cemented basin in a bath-house. Steamboat Springs, Nevada, near Carson City, is another noted fumarole, but no use whatever has been made of this possible source of power. At Ouray, Colorado, are hot springs, the water of which is used in bath-houses and in a few instances to warm dwellings, yet the heat from this highly heated water is sufficient to give a comfortable temperature when desired to every house in the town. It is merely one of many instances of neglect to take advantage of natural resources.

The life of bonds for public improvements in New Jersey is limited by statute as follows, according to the purpose for which the funds are to be expended: stone, concrete, and iron bridges, 30 years; roads and streets built of concrete 6 in. thick, or of blocks of any material, or of sheet asphalt laid on a concrete foundation, 20 years; roads and streets of bituminous concrete, 15 years; macadam roads either water-bound or constructed by the penetration process, 10 years; gravel roads, 5 years.

A decimal system of weights, measures, and currency is advocated by the British Imperial Council of Commerce.

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Industrial Progress

SHORT-CENTRE BELT-DRIVES

One source of power loss is in the slipping of belts, for even the best belt-drive involves about 2% slip, and some drives 5% or more. To overcome this serious loss it has been customary to use long belts or greater tension to get more traction, or belt-tighteners were forced with great pressure against the belts. While slippage can be overcome to a certain extent by

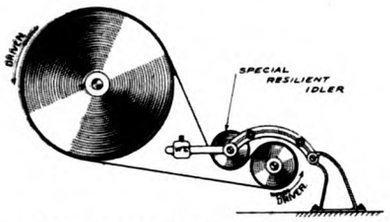


DIAGRAM EXPLAINING PRINCIPLE OF SHORT-CENTRE BELT-DRIVE.

such means, it more frequently results in excessive bearing pressure, over-heating, etc., simply consuming the power by friction at the bearings instead of by belt slippage.

This condition of affairs is responsible for the considerable use of silent chain-drives, with the object of keeping down bearing pressures and getting efficient drives at short centres with freedom from slip. But such drives have about reached their limit on account of high first cost, expense of upkeep, and the constant attention they require, together with the fact that the speed of silent chains is limited to about a quarter of what has been found entirely practicable with good belts and pulleys. On account of the constant tendency toward higher speeds in prime-movers and machines, it was with great interest that the experiments with short-centre belt-drives controlled by yielding idlers, carried on in Europe during the last few years, were watched by the mechanical engineers of this country. The new system involved the use of especially constructed pivoted idlers, mounted on ball or roller bearings, operating against slack belts somewhat in the nature of a belt-tightener, though in principle quite different, as will be explained, and permitted of short centres, at the same time giving greatly increased horse-power with practically no slip. This system was studied by the engineers of the Meese & Gottfried Company of San Francisco, and other Pacific Coast cities, and developed to a high state of mechanical perfection; in fact, this firm is the only one that has gone thoroughly into the engineering of the subject in this part of the country, and though a new undertaking, has already supplied these drives to operate 10,000 hp. The principle can be gathered from the accompanying diagram, and is totally different from a belt-tightener in several important features, as

(1) It does not cause an increase in belt-tension for a given horse-power.

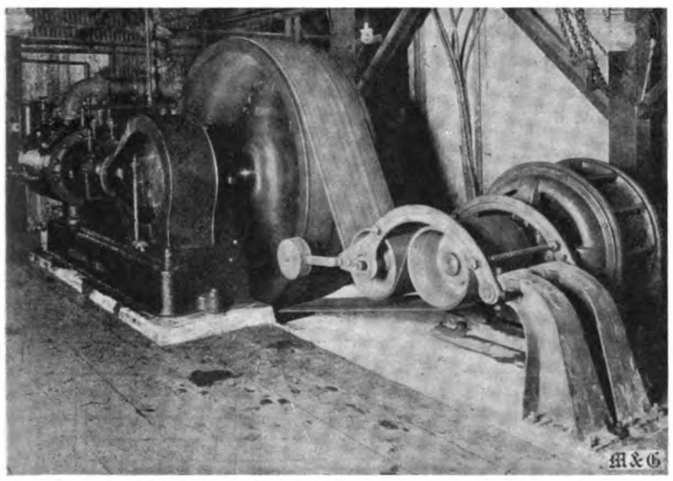
(2) It operates just as satisfactorily on short centres, where formerly a belt-drive would have been impossible.

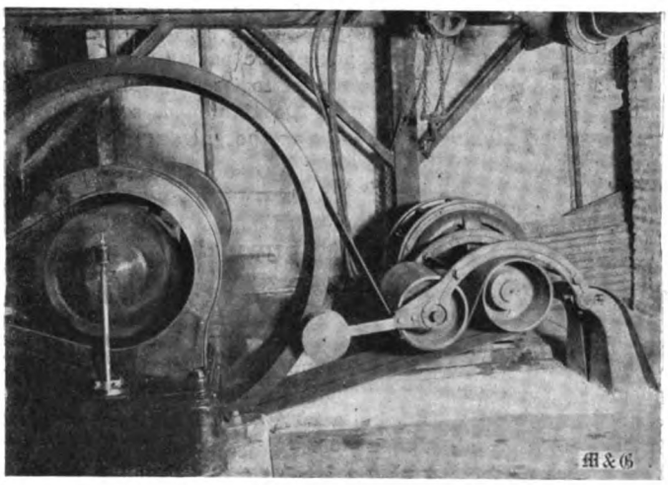
(3) It does not increase the bearing pressure with consequent over-heating and rapid wear of same.

(4) It makes possible the transmission of almost twice the horse-power heretofore considered practicable with a leather belt.

(5) It is easy on the belt and with a good flexible grade of belting it causes no injury.

On first seeing one of these drives the average mechanic would class it as a swinging-belt tightener drive, but would be in error, as can be seen from its distinctive features enumerated above, for it is not merely a 'device' but is more properly a system, the successful installation of which depends on the proper position of the idler, its effective weight relative to the horse-power and speed of the drive, together with the pre-determined slack in the belt, as the belts are purposely made loose. The angle and direction at which the drive runs must also be considered, as the idler may be controlled by weights on levers arranged at the proper angle, or may be pulled upward or sidewise by ropes and counter-weights. On heavily pulsating loads, pneumatic-shock absorbers are sometimes connected to the oscillating frame to steady it. This new development in short-centre belt driving undoubtedly has a great future, as it accomplishes what can be done by no other means —transmitting from the smallest to the heaviest horse-power smoothly and silently at high efficiency, and at speeds which would be quite impossible with silent chains. Practically all belt-drives from the heaviest main drives down come easily within its scope.





PHOTOGRAPHS OF SHORT-CENTRE BELT-DRIVE INSTALLATION IN OPERATION.

These pictures show a Meeseco short-centre belt-drive with a belt 20 in. wide, transmitting 150 hp. from a motor running at 700 r.p.m., to a double-acting duplex air-compressor at 140 r.p.m. Note the close centres of pulleys, 6 ft. 6 in. in this drive.

AN IMPROVED STUFFING-BOX

A great deal of trouble is experienced with the various types of stuffing-boxes in use in the oilfields both on account of the difficulty experienced in packing and also, in the case of those with handles and threaded caps, because sufficient pressure cannot be applied to the packing, and leakage results. A

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stuffing-box recently invented by W. H. Kobbe, of St. Louis, does not have these disadvantages.

The stuffing-box is shown in Fig. 1. There is a flange 10, which is beveled to receive tapered clamp-slips *a*, having gripping-teeth next to the polished-rod. After the adjuster has been regulated, the clamp-slips may be slid on the polished-

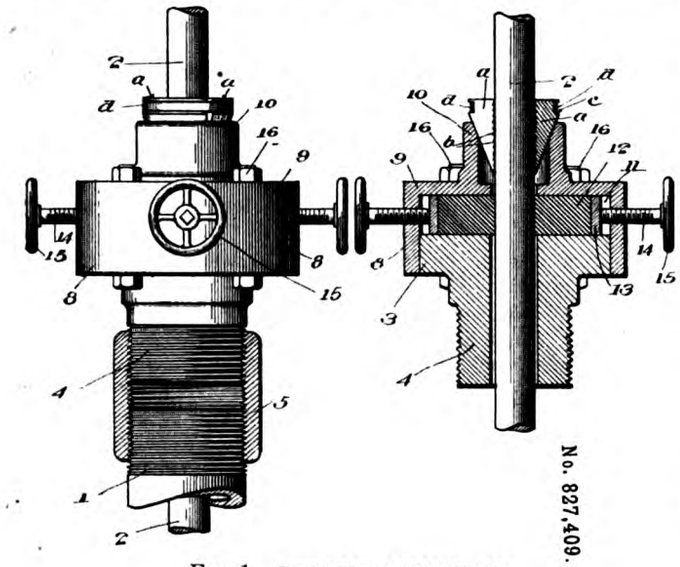

FIG. 1. IMPROVED STUFFING-BOX.

rod until they do not interfere with pumping. The chambers 11 are rectangular in cross-section, and the packing 12 is of similar shape, so that rotative motion of the packing is prevented. A rectangular follower 13 can be regulated by the hand-wheel 15. The inner ends of the packing press against the polished-rod and soon conform to its curvature. As the packing wears, the screws may be tightened, securing uniformly tight packing. In renewing the packing, the bolts 16 are removed and the cap 9 is lifted.

COMPARATIVE RESISTANCE TO CORROSION OF COMMERCIALLY PURE IRON AND OF ALLOYS

Two general hypotheses have been advanced regarding the cause of the corrosion of iron and steel. The first, the 'acid theory,' assumes that the carbon dioxide and moisture in the atmosphere form an acid that attacks the metal, forming ferric hydroxide or rust. Since 1903, however, the 'electrolytic theory' has been most favored. Electrolytic action is believed to be assisted by impurity of the iron or steel and the moisture and other corrosive agents in the air. The greater tendency to corrosion of most of the modern steels in comparison to the older wrought irons is explained by the usually greater amount of impurities present in the steels.

Reasoning along these lines, a number of investigators have concluded that the purer the iron the greater would be its resistance to corrosion. Recent experiments, however, while not comprehensive enough to make it possible to draw sweeping conclusions, indicate that the addition of small amounts of some other metals will increase the resistance to corrosion.

E. A. and L. T. Richardson, in a paper presented at a meeting of the Electro-Chemical Society, September 1916, discussed experiments made by them upon the effect of the addition of copper upon the resistance to corrosion of iron and steel sheets. Sheets of 26-gauge material, including ordinary bessemer and open-hearth steel, charcoal-iron, commercially pure iron, copper-bearing iron, and copper-bearing steel, both bessemer and open-hearth, were exposed to the atmosphere under uniform conditions. The time of failure was taken as the first day when the material was in such a condition that it could be seen to be perforated when the rust was removed by gentle tapping with a blunt instrument such as a file or a nail. At the end of two years and four months, all the specimens except those of copper-steel, had failed, while the copper-steel specimens were still in fair condition. The best results appear to be obtained with an alloy of 0.25% copper.

At the annual meeting of the American Institute of Chemical Engineers in January 1917, Herbert T. Kalmus and K. B. Blake presented a paper reporting the results of an investigation of the effects of adding small amounts of cobalt, nickel, or copper to commercially pure ingot iron. Bars 4 to 6 in. long and 1¼ in. diam. were used. It was found that alloys formed by adding from 0.25 to 3% of cobalt, nickel, and copper to the iron showed greater resistance to corrosion than did the pure ingot-iron.

Engineers' Note Book

DIAGRAM FOR COMPUTING QUANTITY OF MATERIALS FOR HIGHWAY BRIDGES

The accompanying diagrams, taken from the 'Bridge Manual' issued by the Oregon State Highway Department, may be used for computing the quantity of material required for steel highway bridges for both medium and heavy traffic. The bridges

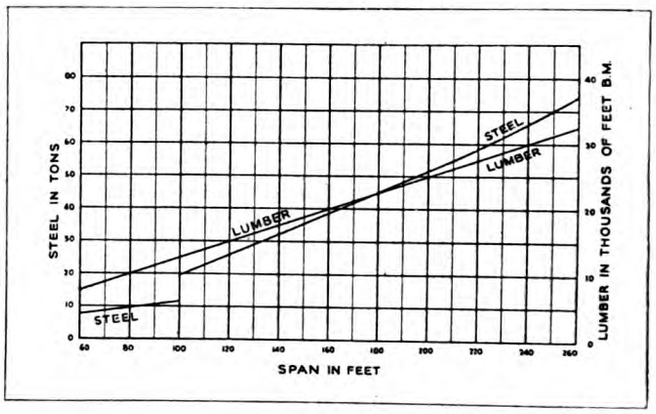

FIG. 1. MATERIALS IN MEDIUM-TRAFFIC BRIDGES.

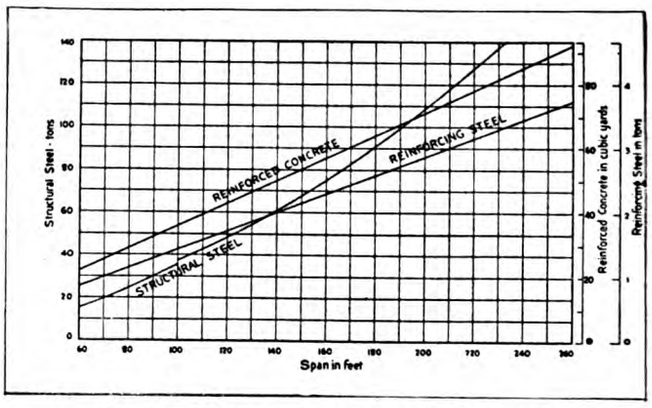

FIG. 2. MATERIALS IN HEAVY-TRAFFIC BRIDGES.

are of the pony-truss type for spans from 60 to 90 ft. and through Pratt trusses for the longer spans. Roadways are taken at 16 ft. wide. Live loads for medium traffic are assumed at 60 lb. per sq. ft. for spans up to 150 ft. and 50 lb. for longer spans. For heavy traffic the live load was assumed at 100 lb. for spans up to 150 ft., and 75 lb. for longer spans. Allowance was made for impact in both cases. Medium-traffic bridges are designed for wood floors and joists, heavy-traffic bridges for concrete floor.

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Civil Service Examinations

INSPECTOR OF GAUGES, March 20. Salary, $2000 to $2400. Frankford Arsenal, Philadelphia. Duties consist of the supervision of the design of gauges, fixtures, etc., required in the procurement of small-arms ammunition, artillery ammunition, and fire-control instruments, supervision of the inspection of all inspecting and working-gauges, supervision of the revision of drawings of gauges and fixtures, and supervision of the inspection of manufactured articles. Competitors will not be assembled for examination, but will be rated on education, technical training, and experience. A degree in engineering from a college or university of recognized standing, and at least three years' experience in a manufactory making arms or ammunition of which not less than one year included the duties of an inspector, are required. Age 25 to 45. Application form 1312.

JUNIOR MECHANICAL ENGINEER, March 21. Salary, $1000. Ordnance Department at Large. The duties of this position will be to investigate and make a comprehensive study of the speeds and feeds of machines. In addition, there will frequently be required practical tests of tool-steels, oils, coals, and other experimental work. Competitors will be examined in the following subjects, which will have the relative weights indicated:

Subjects	Weights
1. Practical questions in mechanical engineering, study of speeds, feeds, etc., of machines, tests of tool steels, oils, etc	40
2. Education and experience	60
Total	100

The completion of at least three years of study in civil, mechanical, or electrical engineering, and, in addition, six months' experience in engineering work preferably along lines similar to the duties of the position or equivalent training and experience are required. Age under 30. Application form 1312. Usual places of examination.

CIVIL ENGINEER AND SUPERINTENDENT OF CONSTRUCTION, March 21-22. Salary, $1500. Duties include supervision of the erection of Army post-buildings, the laying out of grounds, construction of roads, sewers, etc., and, at seacoast posts, wharves. Competitors will be examined in the following subjects, which will have the relative weights indicated:

Subjects	Weights
1. Mathematics, involving a fair knowledge of pure mathematics up to and including elementary calculus	15
2. Theory and practice of surveying and use and care of instruments	25
3. Building construction, specifications, etc	35
4. Training and experience	25
Total	100

At least five years' experience in architectural construction and its supervision on the ground and in civil engineering is required. Graduation in engineering or architecture from a recognized technical school will be equivalent to not more than four years of the five. Age over 20. Application form 1312. Usual places of examination.

JUNIOR ENGINEER, March 21-22. Salary, $1080 to $1200. Water Resources Branch of the Geological Survey. Appointees from this examination will be eligible for promotion to the grades of assistant engineer and engineer. The salaries of assistant engineers range from $1380 to $2000 a year, and of engineers from $2400 to $3000 a year. Competitors will be examined in the following subjects, which will have the relative weights indicated:

Subjects	Weights
1. Mathematics (algebra and geometry)	10
2. Plane surveying	15
3. Irrigation engineering	15
4. River hydraulics	25
5. Water-power engineering	20
6. Education and experience	15
Total	100

The applicant must show that he has graduated in engineering from a college or technical school of recognized standing, or that he is a senior student in such an institution and expects to graduate within six months from the date of this examination. Age 20 to 30. Application form 1312. Usual places of examination.

CALIFORNIA STATE CIVIL SERVICE COMMISSION. Assistant Examiner, State Civil Service Commission, March 17. Salary, $1500. Two years of college training and one year of experience in direct dealing with men employed in skilled trades and allied occupations. Thirty points will be allowed for a written examination covering knowledge of requirements for skilled trades and knowledge of organization diagrams, twenty for a thesis on recruiting and selecting skilled-trade employes for the State service, and fifty for education, experience, and fitness, based on an oral interview. The examination will be held in San Francisco, Sacramento, and Los Angeles. Candidates should obtain application form No. 2 from the State Civil Service Commission, Sacramento, and file same with the Commission on or before March 10.

UNITED STATES CIVIL SERVICE COMMISSION. Tunnel Foreman. Fort Barry, California. Salary, $150 per month. Non-educational examination. Applicants will be rated on physical fitness and experience. They should have had experience in the driving and timbering of tunnels. Application form 1800 should be filed with the Commission at San Francisco by March 21.

Engineering Societies

IDAHO SOCIETY OF ENGINEERS. Ira F. Schaffner, secretary, Boise.

Los Angeles Section of AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Ford W. Harris, secretary, 1029 Higgins building.

Los Angeles Section of AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Carl E. Johnson, secretary, 459 East Third street.

OREGON SOCIETY OF ENGINEERS. Orrin E. Stanley, secretary, room 409, City Hall, Portland.

Portland Section, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Paul Lebenbaum, secretary, 45 Union Depot.

Portland Association of Members of AMERICAN SOCIETY OF CIVIL ENGINEERS. Charles McGonigle, president, care Western Sheet Metal Works.

San Francisco Association of Members of AMERICAN SOCIETY OF CIVIL ENGINEERS. E. T. Thurston, Jr., secretary, Mechanics Institute building.

San Francisco Section of AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Carl F. Braun, secretary, Hooker & Lent building.

San Francisco Section of AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. A. G. Jones, secretary, 811 Rialto building.

Southern California Association of Members of AMERICAN SOCIETY OF CIVIL ENGINEERS. Wilkie Woodard, secretary, 435 Consolidated Realty building, Los Angeles.

UTAH SOCIETY OF ENGINEERS. Hugh C. Lewis, secretary, Capitol building, Salt Lake City, Utah.

The regular meeting of the UTAH SOCIETY OF ENGINEERS was held February 21. The address of the evening was delivered by A. L. Genter on 'Development of Filtration Engineering.'

The regular meeting of the San Francisco Association of

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Members of the AMERICAN SOCIETY OF CIVIL ENGINEERS was held February 20. Assembly bill 1126 for licensing architects and increasing their powers, now pending before the California legislature was discussed and a resolution passed condemning it. A committee was appointed to work against its passage. John D. Galloway, the new president of the association, delivered a brief address contrasting individualistic and state-socialistic ideals. The address of the evening, on 'Efficiency,' by Miner Chipman, emphasized the human element in efficiency. In the importance he places upon this element, Mr. Chipman differs widely from the ordinary 'efficiency expert.'

The PETROLEUM CLUB OF THE UNIVERSITY OF CALIFORNIA has recently been organized. E. K. Hussey is president; L. C. Uren, vice-president; H. V. Slater, secretary; and Ross McCollum, 2600 Bancroft Way, Berkeley, treasurer. Membership is not confined to students, all those interested in the industry being eligible. It is hoped that the oil-men residing in the Bay Cities will join the club and attend its meetings. A series of lectures have been arranged, of which four have been given already, with the aim of developing the general subject from geological conditions to production and refining methods.

Coming Conventions

MID-WEST CEMENT USER'S ASSOCIATION. Annual convention. Omaha, Neb., March 6-10, 1917. Frank Whipperman, secretary, 28th avenue and Sahler street, Omaha.

AMERICAN CERAMIC SOCIETY. Annual meeting, New York, March 5-8. Edward Orton, Jr., secretary, Columbus, Ohio.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION. Annual meeting, New York, March 5-10. T. A. Randall, secretary, Indianapolis.

NATIONAL RAILWAY APPLIANCES ASSOCIATION. Annual meeting, Chicago, March 20. C. W. Kelly, secretary, Kelly-Derby Co., Chicago.

AMERICAN RAILWAY ENGINEERING ASSOCIATION. Annual meeting, Chicago, March 20-22. E. H. Fritch, secretary, 900 South Michigan avenue, Chicago.

PORTLAND CEMENT ASSOCIATION. Spring meeting, San Francisco, April 16-18. H. E. Hilts, Pacific Coast representative, Rialto Bdg., San Francisco.

AMERICAN SOCIETY FOR TESTING MATERIALS. Annual meeting, Atlantic City, New Jersey, June 26-30.

Personal

R. N. KELLOGG has been appointed city engineer for Coquille, Oregon.

R. B. MARSHALL, superintendent of national parks, has resigned.

K. S. HECK, engineer for the bureau of public works at Manila, is in San Francisco.

OLIN ARNSPIGER has been appointed city engineer and water superintendent at Medford, Oregon.

S. E. KIEFFER has been appointed consulting engineer for the Paradise, California, irrigation district.

J. W. KAERTH, county surveyor of Colusa county, California, has been appointed commissioner of assessment district No. 1001.

S. A. JUBB, for several years in charge of harbor construction at Los Angeles, completed his work in that capacity on March 1.

REED BUSH has been appointed deputy State oil and gas supervisor with headquarters at Coalinga, California, succeeding M. J. KIRWAN, who has been transferred to Los Angeles.

A. B. COLLINS has been appointed district engineer of highways for Yakima county, Washington, with headquarters at North Yakima.

R. P. MCLAUGHLIN addressed the Petroleum Club of the University of California, February 15, on 'Water Problems in California Oil Fields.'

J. J. DWYER, formerly president of the California State Board of Harbor Commissioners, has resigned. He has been succeeded by ARTHUR ARLETT.

Major A. A. FRIES, formerly stationed at Yellowstone Park, has been placed in charge of river and harbor work in the Portland, Oregon, district.

W. F. M. GOSS, formerly Dean of the College of Engineering, University of Illinois, has resigned to become president of the Railway Car Builders' Association.

M. H. MURRAY, an oil-well driller of practical experience in several fields, has joined the staff of the Oil and Gas Department of the California State Mining Bureau.

PAUL ELIEL, formerly assistant city manager of San Jose, California, has resigned in order to accept a position with the recently established bureau of municipal research in San Francisco.

ALFRED A. ANDERSON, formerly assistant engineer for the Imperial irrigation district at Calexico, has resigned in order to accept a position with the California State Railroad Commission with headquarters at San Francisco.

H. W. BELL, formerly engineer for the General Petroleum Co. at Coalinga, California, has resigned and accepted a position with the Oil and Gas Department of the State Mining Bureau. His headquarters will be at Santa Maria.

H. C. VENSANO, formerly civil and hydraulic engineer for the Pacific Gas & Electric Co., and JOHN R. and EDWARD G. CAHILL have formed the Cahill-Vensano Co., contracting engineers, with offices at 460 Montgomery street, San Francisco.

W. H. KOBBE, formerly engineer for the Pierce Oil Corporation at St. Louis, is now with the Pierce Fordyce Oil Association, with headquarters at Dallas, Texas. An article by Mr. Kobbe on the 'Recovery of Petroleum from Unconsolidated Sands' appears in this number.

R. K. WEST, engineer for the California State Highway Commission, with headquarters in San Francisco, has been granted a two months' leave of absence, which he will spend in assisting the highway commissioners of Santa Cruz county in preparing plans for a county highway system.

R. B. MORAN, formerly deputy State oil and gas supervisor, with headquarters at Los Angeles, has resigned in order to re-enter private practice. He will be succeeded by M. J. KIRWIN, who has been deputy supervisor at Coalinga. The resulting vacancies will be filled by promotion of other members of the staff of the department.

B. E. CRONKHITE, formerly city engineer of Fresno, California, has resigned. Mr. Cronkhite will now take sole charge for the city of the construction of the sanitary-sewer system now being built and of the storm-sewer system, contract for which will be awarded during this month. C. C. VAN VALKENBURGH, formerly assistant city engineer, has been appointed city engineer.

EARL B. SMITH, formerly associate mechanical engineer for the U. S. Office of Public Roads and Rural Engineering, has been transferred to the Bureau of Soils. He will have his headquarters at Summerland, California, where, in co-operation with J. W. TURRENTINE of the Department of Agriculture, he will investigate the possibilities for the commercial extraction of potash and other chemicals from kelp.

The BLAW STEEL CONSTRUCTION CO. of Pittsburg, has opened a Pacific Coast office at 503 Rialto Bdg., San Francisco, in charge of E. M. Ornitz.

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SAN FRANCISCO, MARCH 5, 1917

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Contracts Pending

Bids will be Received		See Issue of News Bulletin
Mar. 5.	Asotin, Wash., Bridge	Feb. 19
Mar. 5.	Coalinga, Cal., Miscellaneous	Feb. 26
Mar. 5.	Coupeville, Wash., Road Work	Feb. 19
Mar. 5.	Douglas, Ariz., Building	Feb. 26
Mar. 5.	Douglas, Ariz., Street Work	Feb. 26
Mar. 5.	Everett, Wash., Road Work	Feb. 26
Mar. 5.	Hood River, Ore., Road Work	Mar. 5
Mar. 5.	Lewiston, Ida., Machinery and Supplies	Feb. 19
Mar. 5.	Modesto, Cal., Bridges	Feb. 26
Mar. 5.	Napa, Cal., Machinery	Feb. 26
Mar. 5.	Pasco, Wash., Road Work	Feb. 26
Mar. 5.	Prosser, Wash., Bridge	Feb. 26
Mar. 5.	Quincy, Cal., Supplies	Feb. 5
Mar. 5.	Riverside, Cal., Road Work	Mar. 5
Mar. 5.	Sacramento, Cal., Bridge	Mar. 5
Mar. 5.	Sacramento, Cal., Road Work	Mar. 5
Mar. 5.	San Diego, Cal., Street Work	Mar. 5
Mar. 5.	San Jose, Cal., Supplies	Mar. 5
Mar. 5.	San Francisco, Cal., Supplies	Feb. 26
Mar. 5.	San Rafael, Cal., Street Work	Feb. 19
Mar. 5.	Santa Rosa, Cal., Supplies	Eeb. 26
Mar. 5.	Seattle, Wash., Road Work	Feb. 12
Mar. 5.	Sebastopol, Cal., Machinery	Feb. 26
Mar. 5.	Sunnyside, Wash, Water Supply	Mar 5
Mar. 5.	Visalia, Cal., Road Work	Feb. 26
Mar. 5.	Yreka, Cal., Road Work	Feb. 12
Mar. 6.	Bakersfield, Cal., Machinery	Mar. 5
Mar. 6.	Bakersfield, Cal., Miscellaneous	Mar. 5
Mar. 6.	Centralia, Wash., Supplies	Feb. 26
Mar. 6.	Olympia, Wash., Street Work	Feb. 19
Mar. 6.	Olympia, Wash., Street Work	Mar. 5
Mar. 6.	Port Angeles, Wash., Bridge	Mar. 5
Mar. 6.	Stockton, Cal., Road Work	Feb. 19
Mar. 6.	Washington, D. C., Machinery and Supplies	Feb. 19
Mar. 6.	Washington, D. C., Supplies	Mar. 5
Mar. 7.	Bakersfield, Cal., Machinery	Feb. 26
Mar. 7.	Butte, Mont., Street Work	Feb. 26
Mar. 7.	Coquille, Ore., Road Work	Feb. 26
Mar. 7.	Davenport, Wash., Road Work	Mar. 5
Mar. 7.	Dillon, Mont., Bridges	Jan. 22
Mar. 7.	Nezperce, Ida., Sewers	Feb. 26
Mar. 7.	Riverside, Cal., Road Work	Mar. 5
Mar. 7.	San Francisco, Cal., Miscellaneous	Mar. 5
Mar. 7.	San Francisco, Cal., Street Work	Mar. 5
Mar. 7.	St. Helens, Ore., Road Work	Feb. 26
Mar. 8.	Anaheim, Cal., Machinery	Feb. 26
Mar. 8.	Anaheim, Cal., Sewers	Feb. 26
Mar. 8.	Arcadia, Cal., Supplies	Feb. 26
Mar. 8.	Los Angeles, Cal., Street Work	Mar. 5
Mar. 8.	Oakland, Cal., Sewer	Feb. 26
Mar. 8.	Oakland, Cal., Street Work	Mar. 5
Mar. 8.	San Francisco, Cal., Harbor Work	Mar. 5
Mar. 8.	San Rafael, Cal., Road Work	Mar. 5
Mar. 8.	San Rafael, Cal., Water Supply	Mar. 5
Mar. 8.	Seattle, Wash., Machinery and Supplies	Mar. 5
Mar. 8.	Tacoma, Wash., Supplies	Feb. 12
Mar. 9.	Ritzville, Wash., Road Work	Feb. 19
Mar. 9.	Seattle, Wash., Sewers	Mar. 5
Mar. 9.	Seattle, Wash., Street Work	Mar. 5
Mar. 9.	Seattle, Wash., Water Supply	Mar. 5
Mar. 10.	Townsend, Mont., Building	Mar. 5
Mar. 10.	Washington, D. C., Supplies	Feb. 26
Mar. 10.	Winslow, Ariz., Buildings	Feb. 26
Mar. 12.	Modesto, Cal., Road Work	Mar. 5
Mar. 12.	Redwood City, Cal., Culvert	Feb. 26
Mar. 12.	San Bernardino, Cal., Road Work	Mar. 5
Mar. 12.	San Fernando, Cal., Street Work	Mar. 5
Mar. 12.	South Bend, Wash., Harbor Work	Feb. 26
Mar. 13.	Seattle, Wash., Road Work	Feb. 26
Mar. 13.	Ventura, Cal., Building	Feb. 26
Mar. 13.	Washington, D. C., Supplies	Feb. 19
Mar. 13.	Washington, D. C., Supplies	Mar. 5
Mar. 14.	Fresno, Cal., Light	Feb. 26
Mar. 14.	San Francisco, Cal., Railroad Work	Mar. 5
Mar. 14.	Seattle, Wash., Building	Feb. 26
Mar. 15.	Bakersfield, Cal., Buildings	Feb. 19
Mar. 15.	Fort Laramie, Wyo., Irrigation	Feb. 26
Mar. 15.	Powell, Wyo., Irrigation	Feb. 26
Mar. 15.	San Francisco, Cal., Street Work	Feb. 26
Mar. 15.	San Francisco, Cal., Supplies	Mar. 5
Mar. 16.	Seattle, Wash., Building	Feb. 5
Mar. 17.	Adelaide, Cal., Building	Mar. 5
Mar. 17.	Merced, Cal., Building	Mar. 5
Mar. 17.	Tacoma, Wash., Road Work	Mar. 5
Mar. 19.	Everett, Wash., Road Work	Mar. 5
Mar. 19.	Washington, D. C., Harbor Work	Mar. 5
Mar. 19.	Washington, D. C., Machinery	Feb. 19
Mar. 20.	Fairoaks, Cal., Irrigation	Feb. 26
Mar. 20.	Ketchikan, Alaska, Supplies	Feb. 26
Mar. 20.	San Francisco, Cal., Miscellaneous	Feb. 26
Mar. 20.	Washington, D. C., Harbor Work	Feb. 5
Mar. 20.	Washington, D. C., Supplies	Mar. 5
Mar. 21.	Brawley, Cal., Sewer	Feb. 26
Mar. 21.	Brawley, Cal., Water Supply	Feb. 26
Mar. 21.	Edmonds, Wash., Street Work	Mar. 5
Mar. 26.	Los Angeles, Cal., Miscellaneous	Feb. 19
Mar. 26.	Washington, D. C., Buildings	Mar. 5
Mar. 27.	Nogales, Cal., Road Work	Mar. 5
Mar. 27.	San Francisco, Cal., River Work	Mar. 5
Apr. 4.	Gold Beach, Ore., Miscellaneous	Mar. 5
June 1.	Calcutta, India, Sewer	Jan. 2

Building Permits

In SAN FRANCISCO; $2500 and over in valuation.

FEBRUARY 23

Tenement Erection and Alteration—Cost $8000. M. A. Fritz, owner. NW Frederick and Masonic.

(Continued on page 124)

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Construction News

STREET AND ROAD WORK

Colton, Wash.—Plans have been completed and call for bids will be issued soon for paving principal streets of city.

Davenport, Wash.—Bids will be received until March 7 by J. E. Howard, county auditor, for grading and graveling 12 miles of permanent highway No. 3. Estimated cost is $39,000. Plans from G. G. Harvey, county engineer, upon deposit of $5.

Edmonds, Wash.—Bids will be receiveed until 6 p.m., March 21, by J. T. McElroy, city clerk, for construction of two blocks of concrete pavement on Main street.

Everett, Wash.—Bids will be received until March 19 by M. Weatherbee, county auditor, for hard-surfacing permanent highways No. 4, 5, and 34.

Contract for paving Baker avenue has been awarded to Grant & Ervig, Everett, for $11,874.64.

Fairfield, Cal.—Supervisors will request U. S. Department of Agriculture to send highway engineer to assist in planning county highway system.

Holbrook, Ariz.—Election has been called for March 20 to vote on bond issue of $125,000 for construction of county highways.

Hood River, Ore.—Bids will be received until March 5 by K. Shoemaker, county clerk, for construction of about 3000 ft. of highway.

Los Angeles, Cal.—Bids will be received until 9 a.m., March 8, by W. A. Sheldon, secretary board of education, Security Bdg., Los Angeles, for grading grounds at site of Jefferson high school.

Contract for improving Mohawk street has been awarded to C. A. Roberts, 1350 West Temple street, Los Angeles, for $3661.53.

Contract for improving Olive street has been awarded to Fairchild-Gilmore-Wilton Co., Pacific Electric Bdg., Los Angeles, for $10,335.80.

Contract for improvement of Fountain avenue has been awarded to S. McCray, 469 West Avenue 52, Los Angeles, for $4009.71.

Martinez, Cal.—Bids will be received in April for grading and construction of culverts on divisions No. 5 and 6 of county highway system.

Modesto, Cal.—Date of opening bids for construction of 60 miles of concrete-paved highways has been postponed from March 5 to March 12. Bids will be received by Hugh Benson, county clerk.

Nogales, Ariz.—Bids will be received until March 27 by Board of Supervisors for construction of highway to Ruby post-office.

Bids will be received until March 27 by L. Parsons, county clerk, for construction of nine miles of highway, from Silva to New Corral.

Oakland, Cal.—Bids will be received until noon, March 8, by L. W. Cummings, city clerk, for grading and construction of asphalt pavement and brick gutters for 100 lin. ft. on First street.

Bids will also be received until the same time for grading and construction of redwood curbs, concrete gutters and sidewalks, and oil-macadam pavement on Hearst avenue.

Olympia, Wash.—Bids will be received until March 6 by city clerk for paving West Fourth street. Estimated cost is $5000.

Riverside, Cal.—Bids will be received until March 5, by A. B. Pilch, county clerk, for construction of Coral Reef highway.

Bids will be received until 10 a.m., March 7, by A. B. Pilch, county clerk, for construction of 3.5 miles of 4-in. concrete pavement on route No. 15.

Contract for improvement of Market street has been awarded to Johnson-Shea Co., 5th and Market streets, Riverside, for $10,377.44. Other bidders were: Shull-Tucker Co., $10,603.07; W. J. Brand, $11,403.76; W. D. Bohan, $11,593.97; Highway Construction Co., $11,781.08; Peter L. Ferry, $12,805.79; M. T. Shafer Co., $13,312.50.

Sacramento, Cal.—Bids will be received until 10 a.m., March 5, by E. F. Pfund, county clerk, for construction of concrete highway on Grant Line road.

Plans have been completed and call for bids will be issued soon for construction of 23 miles of county highway. Call for bids for construction of 33 more miles of highway will be issued about April 1.

San Bernardino, Cal.—Time of receiving bids for highway improvements in several cities, by L. R. Patty, county clerk, has been postponed until 11 a.m., March 12. Work includes 360,000 sq. ft. of 4-in. concrete pavement.

San Diego, Cal.—Bids will be received until 11 a.m., March 5, by A. H. Wright, county clerk, for construction of asphalt macadam pavement on concrete base on several streets.

San Fernando, Cal.—Bids will be received until 7:30 p.m., March 12, by city clerk, for construction of disintegrated-granite pavement, and concrete curbs, gutters, and sidewalks on several streets.

San Francisco, Cal.—Board of Public Works will receive bids until 2 p.m., March 7, for the following street work: grading and construction of concrete sidewalks, asphalt pavement, and 15-in. sewers on Revere avenue; granite curbs and basalt-block and cobblestone pavement on Manchester street; granite curbs and basalt and asphalt pavement on Naples street; concrete curbs and asphalt pavement on Sillman street; concrete curbs and sidewalks and asphalt pavement on Girard street; concrete sidewalks on Leavenworth street.

Owen McHugh, Russ Bdg., was low bidder at $17,800 and will probably be awarded the contract for construction of boulevard 6000 ft. long at Presidio. Other bidders were: A. E. Buckman, $20,017; M. Fisher, $25,560; J. P. Holland, $27,283; Ehrhart & Greely, $28,750; C. B. Cowden, $28,900; A. J. Grier, $29,970; L. L. Page, $35,450.

Contract for improvement of Jules avenue has been awarded to D. L. Bienfield, Phelan Bdg., San Francisco, for $1252.

Contract for improvement of two blocks on Judah street has been awarded to A. E. Buckman, 352 Geary street, San Francisco, for $14,843.29.

Contract for improvement of two blocks on 42nd avenue has been awarded to Federal Construction Co., Sharon Bdg., San Francisco, for $10,962.30.

Contract for construction of sidewalks on Polk street and on 14th street has been awarded to C. M. Biggs for $114.37 and $61.54 respectively.

Contract for construction of sidewalks on O'Farrell, Belvedere, Gough, Grove, and Clifford streets has been awarded to Owen McHugh for $60.90, $544.20, $56, $159.25, and $135 respectively.

Contract for construction of sidewalks on Geary street has been awarded to P. O'Donnell, 4110½ 25th street, San Francisco, for $195.72.

Contract for improvement of 33rd, Grafton, and Holloway avenues has been awarded to Peter McHugh, 3908 Clay street, San Francisco, for $5184, $3381.39, and $4222.98 respectively.

Contract for improvement of Granada avenue has been awarded to Blanchard-Brown Co., 660 Market street, San Francisco, for $5167.25.

Contract for improvement of Edinburgh street has been awarded to J. F. Dowling, Russ Bdg., San Francisco, for $733.87.

Contract for improvement of Granada avenue has been awarded to Raisch Improvement Co., 1108 Crocker Bdg., San Francisco, for $1955.

Contract for construction of sidewalks on Stockton street has been awarded to P. McDonnell for $351.25.

Contract for improvement of Lee avenue has been awarded to C. B. Eaton, 407 Eleventh street, San Francisco, for $850.

Contract for improvement of Gladys street has been awarded to Flinn & Treacy, First National Bank Bdg., San Francisco, for $1680.

Contract for improvement of one block on 33rd avenue has been awarded to Owen McHugh, Russ Bdg., San Francisco, for $7228.25.

Contract for grading Evans avenue has been awarded to Western Motor Draying Co., 351 Noe street, San Francisco, for $1520.

San Rafael, Cal.—Bids will be received until March 8 by Marin Municipal water district, 825 Fourth street, for construction of highway along pipe-line from Pine Mountain tunnel. Work includes 14¼ acres of clearing, 53,047 cu. yd. excavation, and 1350 ft. of corrugated pipe, from 8 to 36 in. diam. Plans from G. S. Whitaker, secretary of district. Care county clerk, San Rafael.

Seattle, Wash.—Board of Public Works will receive bids until 10 a.m., March 9, for grading and construction of water-mains and concrete curbs and sidewalks on Walker street.

Erickson, Anderson & Hicker, 1002 North Ainsworth avenue, Tacoma, were low bidders at $24,918.36 for construction of concrete pavement on permanent highway No. 15. Engineer's estimate was $21,403.

Tacoma, Wash.—Bids will be received until 11 a.m., March 17,

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by T. N. Morris, county auditor, for paving 3.66 miles of Puyallup highway.

Woodland, Cal.—Contract for construction of sidewalks on several streets has been awarded to John Campbell, 713 North street, for $0.097 per square foot.

SEWERS AND DRAINAGE

Eureka, Cal.—Bids are being received by J. P. Wunderlich, city clerk, for construction of sewer on West avenue.

Globe, Ariz.—Olmsted & Gillelen, Hollingsworth Bdg., Los Angeles, are preparing plans for sewer system.

Hanford, Cal.—Contract for laying 8-in. sewers on Kaweah street and North Harris street has been awarded to J. C. Furby, 1201 North Harris street, for $272.60. Horlock-Clow Co. bid $293.04 and Willett Foster, $308.68.

Los Angeles, Cal.—It will require the official count to determine definitely whether or not the bond issue of $4,450,000 for flood-control has been carried.

Oasis, Utah.—Formation of drainage district comprising 17,000 acres of land in this vicinity is proposed. Estimated cost of work is $350,000. O. L. Crawford, Deseret, is interested.

Sacramento, Cal.—Contract for construction of 6 and 8-in. sewers on several streets and alleys has been awarded to F. E. Frey, 2526 Q street, Sacramento.

BRIDGES AND CULVERTS

Port Angeles, Wash.—Bids will be received until March 6 by J. W. Warren, county auditor, for construction of Lower Hoko bridge.

Sacramento, Cal.—Bids will be received until 10 a.m., March 5, by E. F. Pfund, county clerk, for repair and improvement of Georgianna Slough bridge at Walnut Grove.

San Francisco, Cal.—Cahill-Vensano Co., 460 Montgomery street, San Francisco, was low bidder at $7270, and will probably be awarded the contract for construction of 180-ft. reinforced concrete viaduct at Lobos creek. Other bidders were: Ehrhart & Greely, $7600; Bos & O'Brien, $7967; Clinton Construction Co., $7980; James Currie, $7984; Mahoney Bros., $8390; M. Fisher, $8410; Fred D. Turner, $9487; C. B. Cowden, $10,500; Tibbitts-Pacific Co., $10,830.

Willows, Cal.—John P. Ryan has prepared estimate of $226,000 for cost of proposed bascule bridge at Princeton.

IRRIGATION AND WATER SUPPLY

Colusa, Cal.—Contract for 35,000 cu. yd. of earthwork in connection with strengthening canal-banks for Sacramento Valley West Side Canal Co. has been awarded to C. A. Hische.

Eureka, Cal.—Following bids were received for construction of filter-plant at waterworks: Robert Filter Co., $2325; A. P. Klyne, $3216; California Jewell Filter Co., $4500.

San Diego, Cal.—Bond issue of $682,000 for construction of Lower Otay dam received considerably more than the necessary two-thirds majority. This issue was first voted upon in November, but the bonds failed to carry because of a technicality.

San Francisco, Cal.—State Water Commission has received the following applications for permission to divert water:

U. S. Smelting, Refining & Mining Exploration Co., 582 Market street, San Francisco, 30 second-feet in Plumas county. A fall of 1300 ft. will be obtained and 4300 hp. developed.

Charles K. Fox, Pomona, 1350 second-feet from streams in Modoc county, for irrigation. Estimated cost of work is $800,000.

La Grange Mining Co., Weaverville, 10 second-feet in Trinity county for hydraulic mining.

Southern Pacific Land Co., San Francisco, 2¾ second-feet in Riverside county for irrigation. Plans include submerged concrete dam 400 ft. long and 10 ft. high. Estimated cost of work is $26,000.

Natomas Company of California, Sacramento, 50 second-feet from Sacramento river, for irrigation. Plans include concrete intake, 60-in. steel pipe to sump, 38-in. centrifugal pump, 48-in. pipe-line 5½ miles long, and 17 miles of laterals. Estimated cost is $120,000.

City of Redding, 5 second-feet for municipal supply.

Charles L. Austin, Wilbur Springs, ½ second-foot for milling at quartz mine. Plans include pipe-line 2½ miles long. Estimated cost is $6000.

J. D. Niman, Turlock, 300 second-feet from streams in Mono county for irrigation.

Charles W. Guerin, Pomona, 150,000 acre-feet per annum from tributary of Kern river, for irrigation. Plans include pipe-line and canal 45 miles long.

Charles H. Barton, Oak Bar, water in Siskiyou county for hydraulic mining. Plans include ditch three miles long. Estimated cost is $5000.

Charles E. Knox, 2722 Benvenue avenue, ½ second-foot from springs in Inyo county. Plans include pipe-line eight miles long. Estimated cost is $2000.

San Rafael, Cal.—Bids will be received until March 8 by Marin Municipal water district, 825 Fourth street, for excavation at site of Alpine dam. Work includes 5749 cu. yd. earth and 5363 cu. yd. rock excavation. Plans from G. S. Whitaker, secretary of district, care of county clerk, San Rafael.

Seattle, Wash.—Board of Public Works will receive bids until 10 a.m., March 9, for construction of water-mains on several streets.

Sunnyside, Wash.—Bids will be received until 8 p.m., March 5, by L. W. Bates, town clerk, for construction of new roof on reservoir, including concrete supports.

Waterford, Cal.—Contract for construction of lateral ditches for Waterford irrigation district has been awarded to Frank C. McIntire, 406 North Aurora street, Stockton, at $4879 for lateral B, $600 for lateral No. 2, and $5768 for lateral No. 3.

Waterford irrigation district is considering construction of several reinforced concrete siphons and is receiving bids for this work. E. N. Bryan, Waterford, is engineer for the district.

LIGHT, HEAT, AND POWER

Fallon, Nev.—Nevada Valleys Power Co., Fallon, will construct hydro-electric plant on Truckee river. Building will be of reinforced concrete. About 2500 hp. will be developed.

San Leandro, Cal.—No bids were received for construction of ornamental lighting system in business district.

RIVER AND HARBOR WORK

San Francisco, Cal.—Bids will be received until 11 a.m., March 8, by L. V. Merle, secretary Board of Harbor Commissioners, for construction of pier No. 31. This is to be a concrete and creosoted-pile structure, 150 by 800 ft. long.

Bids will be received until 10 a.m., March 27, at U. S. Engineer Office, 405 Custom House, for dredging about 35,000 cu. yd. of mud and sand from San Joaquin river near mouth of Stockton channel. Detailed specifications on file at office of Western Engineering.

Contract for widening pier No. 40 and construction of railroad-track on north side has been awarded to Clinton Construction Co., 140 Townsend street, San Francisco, for $18,425. Other bidders were: Healy-Tibbitts Construction Co., $19,620; San Francisco Bridge Co., $23,760; Hyde-Harjes Co., $25,730; J. D. Hannah, $28,973.

Contract for construction of concrete and timber bulkhead-wharf adjacent to pier No. 9 has been awarded to Clinton Construction Co. for $14,940. Other bidders were: Healy-Tibbitts Construction Co., $16,192; J. D. Hannah, $22,973; San Francisco Bridge Co., $23,385.

Santa Maria, Cal.—Contract for construction of pile bank-protection on Santa Maria river has been awarded to P. R. Houdek, San Luis Obispo.

Seattle, Wash.—F. W. Allen, Hoge Bdg., Seattle, has completed plans for river work in waterway district No. 3. Estimated cost is $15,000.

Washington, D. C.—Bureau of Yards and Docks, Navy Department, will receive bids until March 19 for repairs and additions to fender-piling and dolphins at naval coal-depot at San Diego.

RAILROAD WORK

Corcoran, Cal.—Construction of 24-mile railroad through beet-sugar region west of Corcoran is proposed. Charles King, Hardwick, is interested.

Klamath Falls, Ore.—Bond issue of $300,000 for construction of railroad by city has been sold to Spizer-Rorick Co., Toledo, Ohio, at par. The bonds bear 6% interest. This will enable the city to construct the railroad.

Lamoine, Cal.—Lamoine Lumber & Trading Co., Lamoine, will construct eight miles of narrow-gauge logging railroad.

San Francisco, Cal.—Board of Public Works will receive bids until March 14 for extension of municipal railroad from Van Ness and Market street to 16th and Church streets. Estimated cost is $90,000.

Southern Pacific Co. has completed foundation work for yards at Visitacion, and is receiving bids for track and yard work.

BUILDING CONSTRUCTION

Adelaide, Cal.—Bids will be received until 1 p.m., March 17, by J. W. Allen, clerk of Lincoln school district, for construction of school building.

Grass Valley, Cal.—Construction of $75,000 hotel is proposed. L. P. Larue, Grass Valley, is interested.

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Los Angeles, Cal.—W. C. Pennel, Baker-Detwiler Bdg., Los Angeles, is preparing plans for ice-skating rink. Estimated cost is $100,000.

Merced, Cal.—Bids will be received until 2 p.m., March 17, by W. H. Robinson, secretary board of school trustees, for construction of high-school building. Plans from Allison & Allison, Hibernian Bdg., Los Angeles, upon deposit of $25.

Middletown, Cal.—Bond issue of $10,000 for construction of high-school building has been voted.

Roseville, Cal.—Pacific Fruit Express Co., Flood Bdg., San Francisco, will construct shops for building refrigerator-cars. Estimated cost is $90,000.

San Francisco, Cal.—Bids are now being received by P. J. Walker Co., Monadnock Bdg., San Francisco, for sub-contracts on construction of 12-story class 'A' building to be constructed at California and Montgomery streets.

Keuffel & Esser Co., 50 Second street, will construct four-story class 'A' building.

Frederick H. Meyer, Bankers Investment Bdg., has completed plans for six-story building to be constructed on Montgomery street near Pine. Call for bids will be issued soon.

Elmer Carlson, 209 Post street, San Francisco, was low bidder at $84,355 for general contract for construction of Fairmount school. A. W. Lawson, 185 Stevenson street, San Francisco, was low bidder at $10,889 for the brick and hollow-tile work. J. E. O'Mara, 445 Minna street, San Francisco, was low bidder at $7988 for heating and ventilating. Alex Coleman, 706 Ellis street, San Francisco, was low bidder at $15,162 for plumbing. Mutual Electrical Co. was low bidder at $5600 for electrical work.

Townsend, Mont.—Bids will be received until noon, March 10, by O. M. Cronk, clerk of school trustees, for construction of building for high school. Plans from G. H. Carsley, Power Block, Helena, upon deposit of $10.

Washington, D. C.—Bureau of Yards and Docks, Navy Department, will receive bids until March 26 for construction of brick and frame buildings at Puget Sound navy yard.

MACHINERY AND SUPPLIES

Bakersfield, Cal.—Bids will be received until 10:30 a.m., March 6, by F. E. Smith, county clerk, for furnishing one 45-hp. road-tractor.

Denver, Colo.—Contract for furnishing steel for bridge at Garfield crossing on Rio Grande project has been awarded by U. S. Reclamation Service to Wisconsin Bridge & Iron Co., Milwaukee, for $16,700.

Contract for furnishing metal-flume for Garfield crossing on Rio Grande project has been awarded by U. S. Reclamation Service to Hardesty Manufacturing Co., Denver, for $6830.79.

Fresno, Cal.—Contract for furnishing from 80,000 to 100,000 bbl. of road-oil to county has been awarded to Union Oil Co. at $1.25 per bbl. f.o.b. cars.

San Francisco, Cal.—Bids will be received until 11 a.m., March 15, by L. V. Merle, secretary State Board of Harbor Commissioners, for furnishing and installing steel rolling doors at pier No. 29.

California Brick Co., 110 Jessie street, San Francisco, was the only bidder at $22.50 and $25 per thousand for furnishing paving-brick to city.

San Jose, Cal.—Bids will be received until noon, March 5, by T. H. Reed, city manager, for furnishing pipe, valves, fittings, and bolts for Alum Rock filter-plant.

Seattle, Wash.—Bids will be received until 11 a.m., March 8, by C. E. Dole, purchasing agent Alaskan Engineering Commission, for furnishing one gasoline-engine and one 9-hp. windlass.

Board of Public Works will receive bids until 10 a.m., March 9, for construction of sewers on East 41st street.

Spokane, Wash.—Bids will be received until March 8 by city purchasing agent for furnishing 1000 ft. of corrugated metal pipe and a 15-ton wagon-scale.

Washington, D. C.—Bureau of Yards and Docks, Navy Department, has postponed opening of bids for furnishing bucket-dredge at Mare Island navy yard from February 26 to March 6.

Bureau of Supplies and Accounts, Navy Department, will receive bids until March 13 for furnishing the following: for delivery at Puget Sound, Wash., 3000 ft. linen fire-hose, 3600 ft. rubber air-hose, schedule 745; 2000 lb. close-link chain, 1100 gross brass nuts, 750 gross iron or steel nuts, schedule 746; 2050 lb. bar monel metal, schedule 747; for delivery at Mare Island, Cal., miscellaneous quantity black and galvanized welded steel pipe, schedule 745; 300 lb. cut copper nails, schedule 746; miscellaneous quantity steel seamless boiler-tubes, schedule 747.

Bids will also be received until March 20 for the following: for delivery at Puget Sound, Wash., 60,000 lb. sheet lead, 70,000 lb. sheet zinc, schedule 756; for delivery at Mare Island, Cal.: 7065 lb. manganese bronze, schedule 756; 57,000 lb. class C angle-steel, 137,500 lb. class B boiler-plate steel, schedule 758. Particulars from Purchasing Pay Officer, U. S. Navy Pay Office, San Francisco.

MISCELLANEOUS

Bakersfield, Cal.—Bids will be received until 10 a.m., March 6, by F. E. Smith, county clerk, for construction of vault for county clerk.

Gold Beach, Ore.—Bids will be received until 10 a.m., April 4, by J. R. Stannard, county clerk, for construction of vault for county treasurer.

Marysville, Cal.—Yuba Construction Co. will build dredge No. 17 for Yuba Consolidated Gold Fields Co. Estimated cost is $600,000.

Portland, Ore.—Contract for construction of concrete lining for two tunnels on Spokane, Portland & Seattle Railroad has been awarded to Porter Bros., Railway Exchange Bdg., Portland, for $75,000.

San Francisco, Cal.—Bids will be received until 2 p.m., March 7, by Board of Supervisors for drilling well at Relief Home.

Seattle, Wash.—Contract for construction of two steel freight-steamers for Cunard Line has been awarded to J. F. Duthie & Co., Seattle.

BUILDING PERMITS

(Continued from page 121)

Three Story Frame Tenements—Cost $30,000. Michael Dempniak, owner. SW Fell and Octavia.

One Story Brick Stores—Cost $4000. Somers Co., owner. S Mission 140 E 7th.

Two Story Frame Dwelling—Cost $3000. E. Goldstein, owner. E 16th Ave 101 N Quintara.

Two Story Steel Sub-Station—Cost $38,000. Pacific Gas & Electric Co., owner. SE Lexington and 19th.

Two Story Frame Dwelling—Cost $3000. J. H. Johnson, owner. W 15th Ave 25 N Balboa.

Two Story Frame Dwelling—Cost $3000. J. H. Johnson, owner. W 15th Ave 50 N Balboa.

Two Story Frame Dwelling—Cost $3000. J. H. Johnson, owner. W 15th Ave 75 N Balboa.

FEBRUARY 24

Two Story Frame Club House—Cost $67,000. San Francisco Golf and Country Club, owner. Rancho Laguna De La Merced (Ingleside).

FEBRUARY 26

Two Story Addition to Store—Cost $100,000. Bankers' Investment Co., owner. SE Geary and Grant Ave.

Two Story Frame Store and Flat—Cost $3900. M. Perpoli, owner. W Sanchez 25 N 30th.

FEBRUARY 27

Two Story Frame Dwelling—Cost $4500. Geo. W. Hind, owner. E 17th Ave 275 S Cabrillo.

Two Story Frame Dwelling—Cost $4500. Geo. W. Hind, owner. E 17th Ave 300 S Cabrillo.

Two Story Frame Dwelling—Cost $4500. A. R. Walther, owner. E 26th Ave 60 S Balboa.

Three Story Frame Tenements—Cost $13,000. Jas. Cantley, owner. W Laguna 112 N Pine.

Two Story Frame Dwelling—Cost $2900. F. Nelson & Sons, owners. E 28th Ave 257 N Irving.

Two Story Frame Dwelling—Cost $3000. F. Nelson & Sons, owners. N Portola Drive 200 E 15th Ave.

One and One-Half Story Frame Dwelling—Cost $2500. F. Nelson & Sons, owners. E 29th Ave 239 S Lincoln Way.

Two Story Frame Dwelling—Cost $8000. Dr. A. J. Villain, owner. NW San Rafael and St. Francis Blvd.

FEBRUARY 28

Two Story Frame Dwelling—Cost $5900. Nelson Bros., owners. NE Balboa and 18th Ave.

Two Story Frame Dwelling—Cost $4700. Nelson Bros., owners. E 18th Ave 25 N Balboa.

Two Story Frame Dwelling—Cost $3950. Nelson Bros., owners. N Balboa 82 E 18th Ave.

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